GRAPHIC METHODS
IN EDUCATION
WILLIAMS

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IN EDUCATION

EDITED BY ELLWOOD P. CUBBERLEY

PROFESSOR OF EDUCATION
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GRAPHIC METHODS IN EDUCATION

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EDITOR'S INTRODUCTION

The present volume in this series of textbooks arose from an attempt to meet a very practical need in educational administration, namely, that of giving to prospective school principals, superintendents, and research workers such simple training in graphic methods as they need, without the necessity of sending them to the engineering courses in Lettering, Linear Drawing, and Design for an analogous but less useful type of training.

I was first attracted to the idea of teaching Graphic Methods in Education by the skillful work of Dr. Spaulding, nearly a decade and a half ago, in "selling," as we now say, his educational ideas to the people of Newton, Massachusetts, which he did in part by means of numbers of carefully constructed graphs and charts. The later rise of the school-publicity idea; the work of a few of my students who could draw in holding their communities to an educational program by the use of charts, and lantern slides made from them; together with the poorly organized and poorly drawn charts submitted by most of my students — alike combined to confirm in me the idea that some simple form of instruction in graphic methods ought to be given in schools of education.

Turning to one of our former graduate students, Dr. Williams, whose chart work as a student was always good, and whose later work as Director of the California Bureau of Juvenile Research was noteworthy for the excellent charts he prepared, I asked if this ability to draw good charts was not something that could be taught without any great expenditure of time or effort. He answered that it could, and I then invited him to offer a course in Graphic Methods at Stanford University, during the summer quarter of 1918.

The work proved so successful that it has been continued each summer quarter since. Recently the work came to be in such demand that it has been repeated in the winter quarter as well, and one of our staff has now taken it over as a regular part of his teaching load. The course is supposed to require about six hours a week of the student's time for twelve weeks, carries two units of university credit, and is made supplemental to courses in statistics

and administrative procedure. The description of the course in the university announcements now reads as follows:

188. *Graphic Methods of Presenting Facts.* This course is designed to give practice in the methods which are serviceable in the popular portrayal of statistical data. In addition to graphic presentation, some attention will be given to a consideration of the merits of various tabular arrangements of material and to desirable methods of school publicity. There are no prerequisites for the course, but a knowledge of lettering is desirable. Intended primarily to show prospective school officers how best to display statistical facts.
2 units, winter and summer quarters. (Almack.)

This volume is an outgrowth of the organization and presentation of the course. In it the author has given the rules for preparing and judging charts, and has greatly simplified charting procedure by reducing all graphic presentations to fifteen main types. These he has described and illustrated in Chapters III to XVII inclusive. He has also pointed out in these chapters when each type of chart can be most effectively used. In this form it is hoped that the results of what has been worked out at Stanford may prove useful to school officers generally, and as a teaching manual for schools of education elsewhere. It ought to be added that the same principles and methods and procedures and standards here outlined will prove equally useful for workers in the different fields of social service.

The importance of good graphic displays for a principal or a superintendent of schools, trying to carry through a progressive school policy, either in a school building or in a city or a county school system, is something that should not be underestimated. While correct knowledge as to educational procedure is, of course, fundamental, the ability to show the results of procedures in easily understandable form is also important if a body of teachers or a community is to be carried along with a progressive principal or superintendent. Since a good graphic display tells so much, and is so much more condensed and effective than a verbal description, principals and superintendents ought to use graphic methods freely in talking to the public. To be most effective, graphic displays should not only be well made and lettered, but they should also conform to standard procedures in construction. They should, furthermore, be so scaled and drawn and lettered as to make possible their reproduction as lantern slides or as news-article il-

lustrations. While others may be trained and used to do the actual work of preparing the graphic displays, where many need to be prepared, the thinking out of the contents and form and scale of the charts, and the making of rough sketches for them, will always be the work of the principal or the superintendent or research worker for the school system. To give simple training to prospective school officers in the underlying principles of good graphic presentation is to add one more effective tool to their equipment for service.

Ellwood P. Cubberley

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GRAPHIC METHODS IN EDUCATION

CHAPTER I

THE PURPOSE AND VALUE OF GRAPHIC METHODS

Why we use charts. If we look through a book, monograph, or periodical of recent date in the field of education, psychology, or the social sciences, we are very likely to find that the text is illustrated with charts. This is particularly true in the case of articles dealing with the results of tests and measurements, and reports of surveys of educational or social conditions. The *Boise Survey*, for example, a book of thirteen chapters, contains thirty-nine graphic illustrations. These charts portray the present and proposed organization of the school system, the efficiency of the instruction, the condition of the buildings, the age-grade distribution, the results of standardized tests, the results of health supervision of the children, relative costs and expenditures, the extent of the curriculum, and many other facts which tell clearly and concisely what the people of Boise are getting for the quarter of a million dollars they spend each year for public education. In the recent study of *Social Conditions in An American City*, published by the Russell Sage Foundation, and which is a social survey of the city of Springfield, Illinois, many charts and illustrations were used in presenting the significant facts disclosed. Professor G. C. Whipple, in *Vital Statistics*, shows how graphic methods may be used effectively in acquainting the public with such data. Recent bulletins by the research department of the National Education Association further illustrate the chart method of disseminating public information. Dr. Ayres's report on *The War with Germany*, an official Government publication, is devoted chiefly to graphic summaries. Reports of city school superintendents in many cities show an increasing tendency to use charts in setting forth the growth and future needs of the school system.

Publications making use of this illustrative method stand out in sharp contrast to the stiff verbal and numerical reports which characterized educational publications of former years. Long columns of figures give an impression of accuracy, but are lacking in interest for the average reader. Moreover, it is extremely difficult, for many persons, adequately to grasp the meaning of numbers presented in statistical columns. Psychologically, some form of mental comparison is necessary for an understanding of numerical values, and most persons tend to make these comparisons through a procedure of the imagination which is not unlike the construction of a chart. The amount of mental work can be reduced by presenting the facts at the outset in graphic form.

Charts, then, are a means of objectively clarifying our thinking with reference to facts. They also help to fix the attention of the reader, and are often the sole cause for turning his thoughts in a direction which might otherwise have been avoided. It is obvious that a taxpayer of Boise, seeing the whole curriculum of the elementary schools presented in a single chart, can form a better idea of what the schools are doing than if he took the time and expended the energy necessary to peruse a written description of it; which latter method might conceivably have served only to confuse his mind, without contributing much to his information, or arousing his interest. Few average citizens of American cities would take the time to read a purely verbal account of the health conditions of Springfield, Illinois; and yet the single chart, showing the whole problem of contagious diseases as it affects that city, has doubtless attracted the attention of thousands of men and women in Springfield and elsewhere, whose interest in public health, thus aroused, may find practical expression in the betterment of living conditions.

Dr. Willard C. Brinton, in his pioneer work entitled *Graphic Methods for Presenting Facts*, says:

We daily see facts presented in the hope of creating interest and action for some really worthy piece of work to benefit the people as a whole. In many of these cases the attitude of the person presenting the matter seems to be that the facts will speak for themselves and that they need little or no assistance. Ordinarily, facts do not speak for themselves. When they do speak for themselves, the wrong conclusions are often drawn from them. Unless the facts are presented in a clear and interesting manner, they are about as effective as a phonograph record with the phonograph missing.

The growth of the social sciences. Education and applied sociology are rapidly acquiring places in the realm of science. This means that the subject-matter with which they deal is becoming better organized and adaptable to numerical evaluation and comparison. The introduction of tests and measurements in educational procedure is believed by many educators to have been the most significant constructive factor in the whole history of education. The work of the schools is now a measurable product. The output of a single pupil, a class, a grade, a school, or a city may be compared, unit for unit, in quantity and quality, with that of other pupils, classes, grades, schools, or cities, or with generally accepted standards. In practical social work also the trend is toward scientific procedure, aiming at standardized measurement and the comparison of numerically expressed facts. The progress of any science may be said to depend upon the extent to which its procedure is based on measurement. Professor E. L. Thorndike recently said: "I am suspicious of educational achievements which are so subtle and refined and spiritual that they cannot be measured. I fear that they do not exist."

Experimental work in human science. Professor W. A. McCall has called attention to the stages through which education has passed, following the course of the other sciences, in the determination of truth. First came the stage of *authority*, in which all questions were referred to persons whose experience, general information, or position was assumed to justify their indisputable opinions. In those dark days the facts were neither sought nor desired. The second stage, into which Professor McCall believes American education to be now well advanced, is that of *speculation*. It is characterized chiefly by freedom of discussion in matters in which different opinions arise through experience or theorizing. The third stage, which we are entering with rapid strides, is that of *experimentation*. Here we no longer submit to mere opinion, nor do we decide fundamental issues from the trend of discussion; we collect the data, evaluate or measure the facts, and subject them to numerical comparison.

The increasing usefulness of the human sciences urges the development of efficient methods for presenting the facts to the public, and to the technical workers who are devoting their lives to them. For this purpose the chart method has already demonstrated its value. Inasmuch as nearly all facts can be presented in graphic form, it ought logically to follow that the extensive use

of charts will stimulate public interest in human-welfare problems, and increase the practical usefulness of the multitude of new ideas which are daily arising from experiment and research.

Administrative problems. Among the many problems with which the public is concerned are those dealing with the administration of education. Professor Alexander has pointed out how errors of presentation may result in misleading statements. In one case a superintendent of schools was charged with being responsible for what was alleged to be an alarming increase in the proportion of illiteracy in his city. An analysis of the facts showed that the amount of illiteracy was really so small that when a few ignorant families changed their place of residence the *number of cases* of illiteracy within the city limits was doubled. The actual percentage of illiteracy for the population of the city, however, was affected only to a negligible degree. Whether the misinterpretation was intentional or not, it must have been accepted by a large part of the reading public, who, because of the dry and uninteresting way in which statistical findings are usually presented, preferred rather to take the inference on its apparent face value than to seek out the error.

Reports of city school systems are often justly criticized because of their lack of interest for the taxpayer. It is a common thing to limit the edition of such reports and to send copies only to public officials and libraries. It is believed to be an unnecessary expense to attempt to have them read by the average citizen. This procedure may, of course, be economical; and usually such evaluation of the readability of the report is correct. Official reports, however, need not be uninteresting and unattractive, even although they are based largely upon statistics. The "average citizen" is not disinclined to listen to facts; on the contrary, he is desirous of adding to his information any facts which are related to his welfare. He requires only that they be relieved of their technical style, and that they be placed before him as clearly as the news furnished by his daily paper.

From the extensive development of the motion picture industry we may obtain a suggestion regarding the practical superiority of visual over verbal presentation. A picture play which can be shown in two hours will be seen and appreciated by thousands of persons who would never have read the novel on which it is based. The use of educational motion pictures in the schools has been found profitable for similar reasons. Graphic advertising, the

major salesman for many products, has demonstrated that the attention of the public can be drawn in any direction if the appeal is properly made. It is not verbal descriptive matter, but pictures, which sell tooth brushes, soap, automobiles, furniture, chewing-gum, kodaks, cereals, and other products needed by the public. (See Figs. 1, 2, and 3.) The sale of educational ideas may not be accomplished as easily, but the principle of visual appeal must be taken into account.

FIG. 1. ILLUSTRATION OF THE USE OF THE PICTURE METHOD OF APPEAL IN ADVERTISING

This method is now almost universal and has been found experimentally to be superior to verbal presentation for attracting and holding the attention.

Publicity campaigns. Alexander and Theisen show how special campaigns have been launched for the purpose of making educational facts known to the public. The need for new and larger school buildings, the need for better salaries, the increase in attendance, the improvement of the age-grade distribution, the health conditions in the schools, and the relative educational position of a city with other cities of its class, all of which can be shown graphically, are among the sets of facts suitable for such campaigns. In some cities the appeal has been so successfully made

with the aid of pictures and drawings that many more than the usual number of voters turned out at the school election, with the result that bond issues were easily carried. The intelligent citizen usually favors school improvement, but his interest must be aroused if his vote is to counterbalance that of the chronic "kicker" who opposes school issues from force of habit, and who never fails to cast his ballot. Even such a person eventually may yield to the force of clearly presented facts.

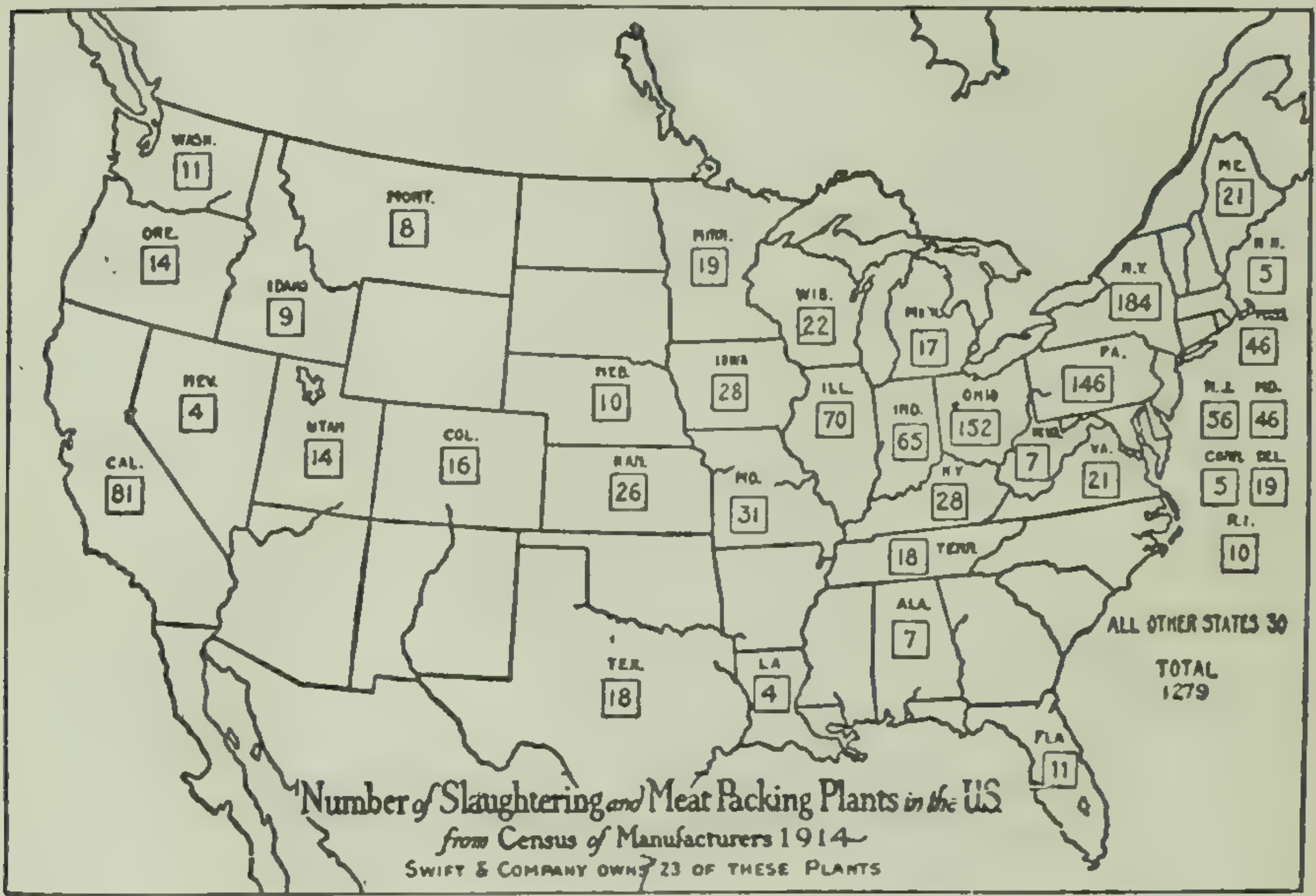

FIG. 2. A GRAPHIC REPRESENTATION OF THE RANGE OF BUSINESS OF A LARGE CORPORATION

This is one of several charts used by them in advertising, to acquaint the public with the type of service they render.

Mr. Gardner T. Swarts gives an interesting use of a map by a school superintendent. Of this he says:

> He knew that a new school was required in a certain district because the child population was centered there. A certain alderman, however, was anxious to sell land in another district. While the matter was under consideration, this school superintendent had a pin map made, showing the location of the home of every child of school age within the city limits. He also showed the two proposed locations for the school. This map was displayed in a store window for a long period, and the superintendent found it convenient to be handy where people could ask him questions, as much of the time as he could spare. The result was that when the matter came up for final decision, the school superintendent, and incidentally the welfare of the city, won out.

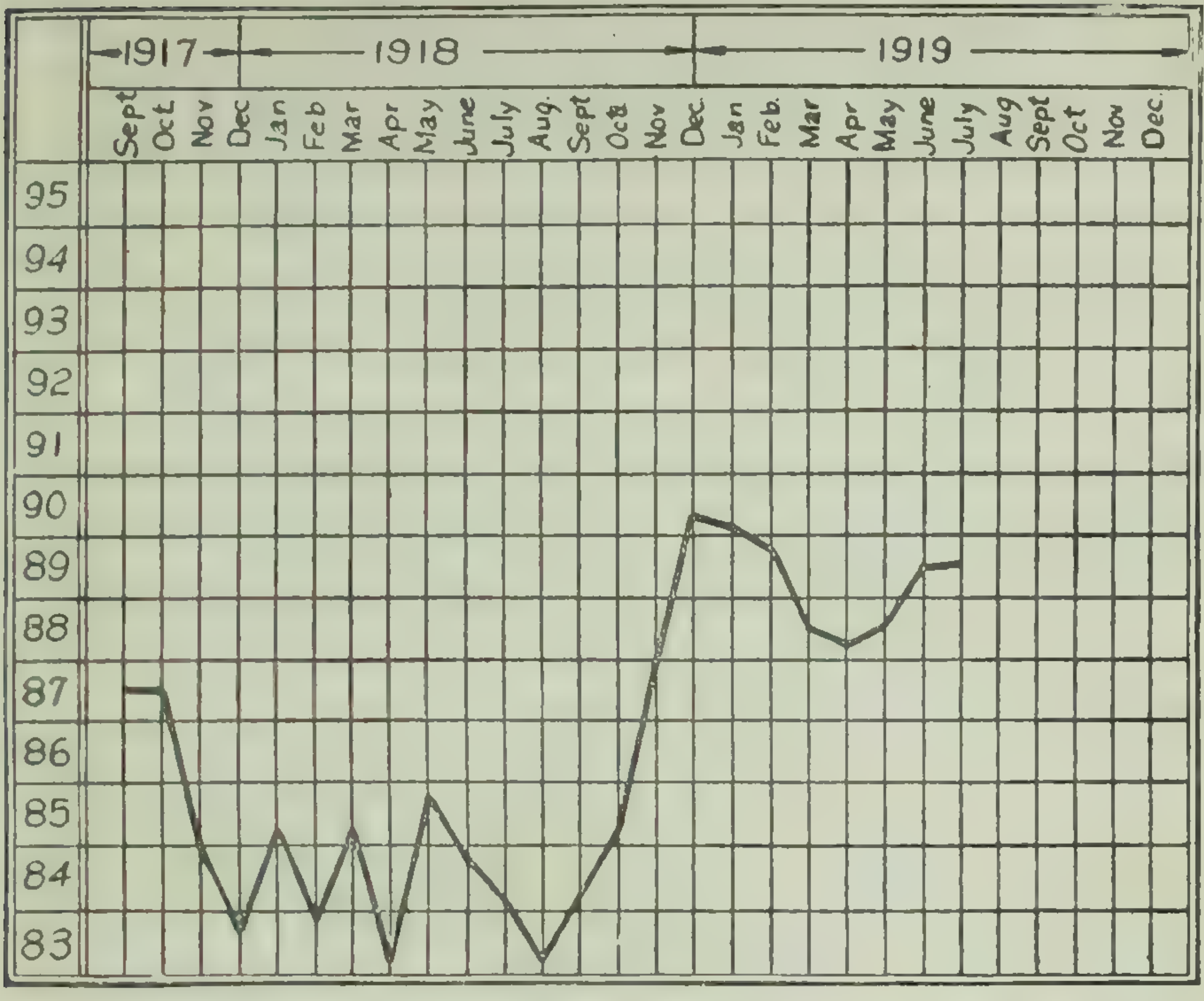

FIG. 3. TREND OF LOCAL BOND PRICES IN A WESTERN CITY

This chart appeared in a daily newspaper, and was read and understood by thousands of men who follow the markets. It is not too technical or statistical for this purpose, and presents the facts in a way that is easily grasped. The chart is incorrectly drawn, as the base line does not show. (See Chapter VI.)

Graphic methods for text illustration. Whether the monks of the Middle Ages realized it or not, they were following a sound psychological principle in their "illumination" of religious manuscripts. To-day the illustration of books and magazine articles is considered a necessity. In published writings dealing with statistical data, the illustrations consist of charts. The originals of these charts are drawn in black ink on white paper, and made considerably larger than the desired printed size. This tends to promote accuracy in the original drawing, and to cover up slight defects through the reduction.

When the chart is completed, the extent of its proposed reduction in size is determined, and it is reproduced through the photoengraving process. The drawing is photographed on a sensitized zinc plate, which is so chemically treated that the white portion is dissolved away, and the black or inked-in portion stands out in

relief. The plate is then fastened to a block of wood of the proper thickness to correspond with the height of printer's type. The engraving is known as a "zinc etching," or "line cut." When placed in the printing press the raised portion receives the ink, and when in contact with the paper produces a correct impression of the original chart. Although usually of smaller size, the proportions remain the same.

The aim of this book. It is the purpose of this book to show how easily charts can be made, even by inexperienced persons, and by those who possess no better than ordinary ability in drawing; how effectively charts can be brought into use in the representation of educational and sociological facts; how to choose the kind of chart which is most effective for a given purpose; how to avoid the errors which uninstructed persons are likely to make in drawing charts; and how to judge the worth of a finished chart. The method has already been found applicable to many fields — engineering, transportation, business administration, insurance, public health service, meteorology, and others. For the purpose of this book the material is gathered almost entirely from recent investigations in education and related sociological work.

QUESTIONS AND TOPICS FOR DISCUSSION

1. Enumerate some recent educational reports which have been improved by the use of charts, and point out in what ways.
2. What psychological principle is involved in the appeal which charts have been found to have?
3. Why do official reports so often fail to impress the persons to whom those making the reports are responsible?
4. Are statistics always "dry" and uninteresting? Under what conditions may they be made more useful?
5. Through what stages has human thinking passed with regard to the determination of truth? Why has education been relatively slow to reach its present stage?
6. From present indications, what may we expect of educational progress in the near future? What factors have contributed to this development?
7. How is school administration concerned with methods of representing facts?
8. What great industries depend chiefly upon visual appeal?

9. What good results have been obtained through educational publicity campaigns?
10. Why are most books and magazines illustrated? What is the present tendency relative to the illustration of educational publications?

SELECTED REFERENCES

I. Books on Statistical Procedure and Graphic Methods

Alexander, Carter. *School Statistics and Publicity.* New York: Silver, Burdett & Co., 1919. Pp. 332. (Chapter on "Graphic Methods.")

Alexander, C., and Theisen, W. W. *Publicity Campaigns for Better School Support.* Yonkers: World Book Company. Pp. 164.

Brinton, W. C. *Graphic Methods for Presenting Facts.* New York: The Engineering Magazine, 1914. Pp. 371.

Gilman, Stephen. *Graphic Charts for the Business Man.* Chicago: La Salle Extension University, 1922. Pp. 62.

Jones, D. C. *A First Course in Statistics.* London: G. Bell & Sons, 1921. Pp. 286.

Kelley, T. L. *Statistical Method.* New York: The Macmillan Company, 1923. Pp. 390. (Chapter on "Graphic Methods.")

King, W. I. *Elements of Statistical Method.* New York: The Macmillan Company, 1913. Pp. 250. (Chapter on "Graphic Methods.")

McCall, W. A. *How to Measure in Education.* New York: The Macmillan Company, 1922. Pp. 416. (Chapter on "Graphic Methods.")

Rugg, Harold O. *Statistical Methods Applied to Education.* Boston: Houghton Mifflin Company, 1917. Pp. 410. (Chapter on "Graphic Methods.")

Secrist, Horace. *An Introduction to Statistical Methods.* New York: The Macmillan Company, 1920. Pp. 482. (Chapter on "Graphic Methods.")

Swarts, Gardner T. *Notes on the Use of Pin Maps and Charts by Health Officers.* Providence: Educational Exhibition Company, 1917. Pp. 24.

Whipple, G. C. *Vital Statistics.* New York: John Wiley & Sons, 1919. Pp. 517. (Chapter on "Graphic Methods.")

II. Recent Publications Containing Illustrative Charts

American Social Hygiene Association. *Charts on Social Hygiene Facts.* 1919.

Ayres, Leonard P. *The War with Germany. A Statistical Summary.* Washington: Government Printing Office, 1919. Pp. 154.

Brigham, C. C. *A Statistical Study of American Intelligence.* Princeton University Press, 1923. Pp. 210.

Burdge, Howard G. *Our Boys.* New York Military Training Commission, 1921. Pp. 345.

Cubberley, E. P. *Public School Administration.* Boston: Houghton Mifflin Company, 2d ed., 1922. Pp. 479.

Cubberley, E. P. *School Organization and Administration* (based on Salt Lake City School Survey). Yonkers: World Book Company, 1916. Pp. 340.

Cubberley, E. P. *The Principal and His School.* Boston: Houghton Mifflin Company, 1923. Pp. 571.
Cubberley, E. P. *The History of Education.* Boston: Houghton Mifflin Company, 1920. Pp. 849.
Ellis, A. C. *The Money Value of Education.* United States Bureau of Education, Bull. 1917, no. 22.
Harrison, S. M. *Social Conditions in an American City.* (The Springfield Survey.) New York: Russell Sage Foundation.
National Education Association. *Research Bulletins.* Issued from Headquarters, Washington, D.C.
New York State Hospital Commission. *Annual Statistical Review.* Albany, New York.
Prudential Life Insurance Company. *Statistical Charts Relating to Accidents, Influenza, Tuberculosis, and Cancer.* Newark, New Jersey.
Sears, J. B. *The Boise Survey.* Yonkers: World Book Company, 1920. Pp. 289.
United States Bureau of Education. *Requirements for the Bachelor's Degree.* Bull. 1920, no. 7.
United States Bureau of Education. *Statistics of City School Systems.* Bull. 1920, no. 24.
United States Children's Bureau. *Save the Youngest.* Pub. no. 61, 1919.
Whittier State School. *Biennial Reports*, 1916, and 1918. Whittier, California.
Williams, J. Harold. *The Intelligence of the Delinquent Boy.* Whittier, California: Journal of Delinquency Monograph no. 1, 1919. Pp. 200.
Williams, J. Harold. *A Survey of Pupils in the Public Schools of Bakersfield, California.* Whittier, California: Whittier State School, Research Bulletin no. 9, June, 1920. Pp. 43.

CHAPTER II

THE PREPARATION OF CHARTS

What is a chart? For our purposes a chart is a drawing which represents a fact, a group of facts, or an idea. The desired thought may be represented in many ways — for example, by the size of a square, the length of a bar, the size of a circle, the trend of curve, the position of a dot, or a picture of an object. The purpose of a chart is to give a clearer meaning to the idea or facts which it represents.

Most charts consist of line drawings, accompanied by explanatory words and numbers. Ideally, the drawing should express the thought so clearly that the amount of wording and numbering may be reduced to a minimum.

Size and form of charts. In general, charts may be divided into three types, according to the uses to which they are put:

(1) Charts drawn for publication.

(2) Charts drawn for use in typewritten or manuscript reports not intended for publication.

(3) Display charts.

Published charts are usually reduced in size from the originals from which they are made. The reduction through the photo-engraving process helps to cover up slight defects and produces a generally improved appearance. Most charts for books and periodicals of ordinary size may be drawn satisfactorily on letter-size paper ($8\frac{1}{2} \times 11$ inches). They are made on white paper with black ink only, as colors cannot be reproduced in a single engraving. The engraver reproduces only the black-ink portion of the copy submitted to him, and after the engraving or "line cut" is made the original drawing is no longer needed.

For incorporation in a report which is not to be published there will, of course, be no change in the size of the chart after it is drawn. It may be made in colors if desired. Charts of this type require more care than those from which engravings are to be made, for their permanent appearance will be just as they come from the drawing-board. In this case not only the chart, but the entire sheet of paper on which it is drawn, will be subject to inspection.

Display charts are those which are intended for use in display frames for hanging on the wall, or for other exhibit purposes. They are usually large, and are often made in colors. These also are produced in finished form, and do not go through the engraving process.

General statement of procedure. The first step in the making of a chart is the collecting or compiling of the data. The second step is choosing the form of chart which will best serve the purpose. In making this choice it is advisable to draw a rough penciled outline of each of the forms considered, having in mind the general finished appearance, the purpose for which the chart is to be drawn, and the type of reader to whom the facts are to be presented. The size is then determined upon, and the chart is "laid out" accurately in penciled lines. The next step is the inking-in of the lines to be retained. The final step is "cleaning up" the chart, including the erasing of all remaining pencil lines and the removal of accidental ink marks occasioned by slips of the pen.

1. Materials and instruments

Drawing-board. The size of the drawing-board will depend upon the size of the charts to be made. Most of the charts represented in this book were made on letter-size paper, which can be easily handled on a small board. The 16 × 21 inch size of board is recommended for the making of such charts. Other common sizes are 12 × 17, 16 × 24, and 20 × 26. The smaller and thinner boards are not satisfactory for making charts of the kind illustrated here. The board should be of good quality soft wood, preferably of at least three-fourths-inch thickness, and bound at the ends by narrow strips of wood running crosswise of the grain of the remainder of the board. The end strips help to prevent warping, and give the board four smooth sides. One edge of the board, usually one of the cleated sides, will be found to be the smoothest and straightest. This should be used as the left side, against which the T-square will be operated. If one edge of the board is not smooth and straight, it cannot be used with success. It is not so important that all sides be suitable for T-square use, although their being so is desirable.

Although drawing-boards are approximately square cornered, it rarely happens that any one side is exactly perpendicular to either of its adjacent sides. This fact should be kept in mind in laying out vertical lines, which should be made with the triangle,

and not with the T-square placed against the bottom or top of the board.

The smoothness of edges and surface are so essential to good work that the drawing-board should receive good care. A relatively slight depression or dent may cause numerous imperfections in the charts, and subsequent loss of time.

T-square. The purpose of the T-square is to serve as a guide or rule for drawing horizontal lines, and as a base upon which the triangle is operated for drawing vertical lines. Inasmuch as the

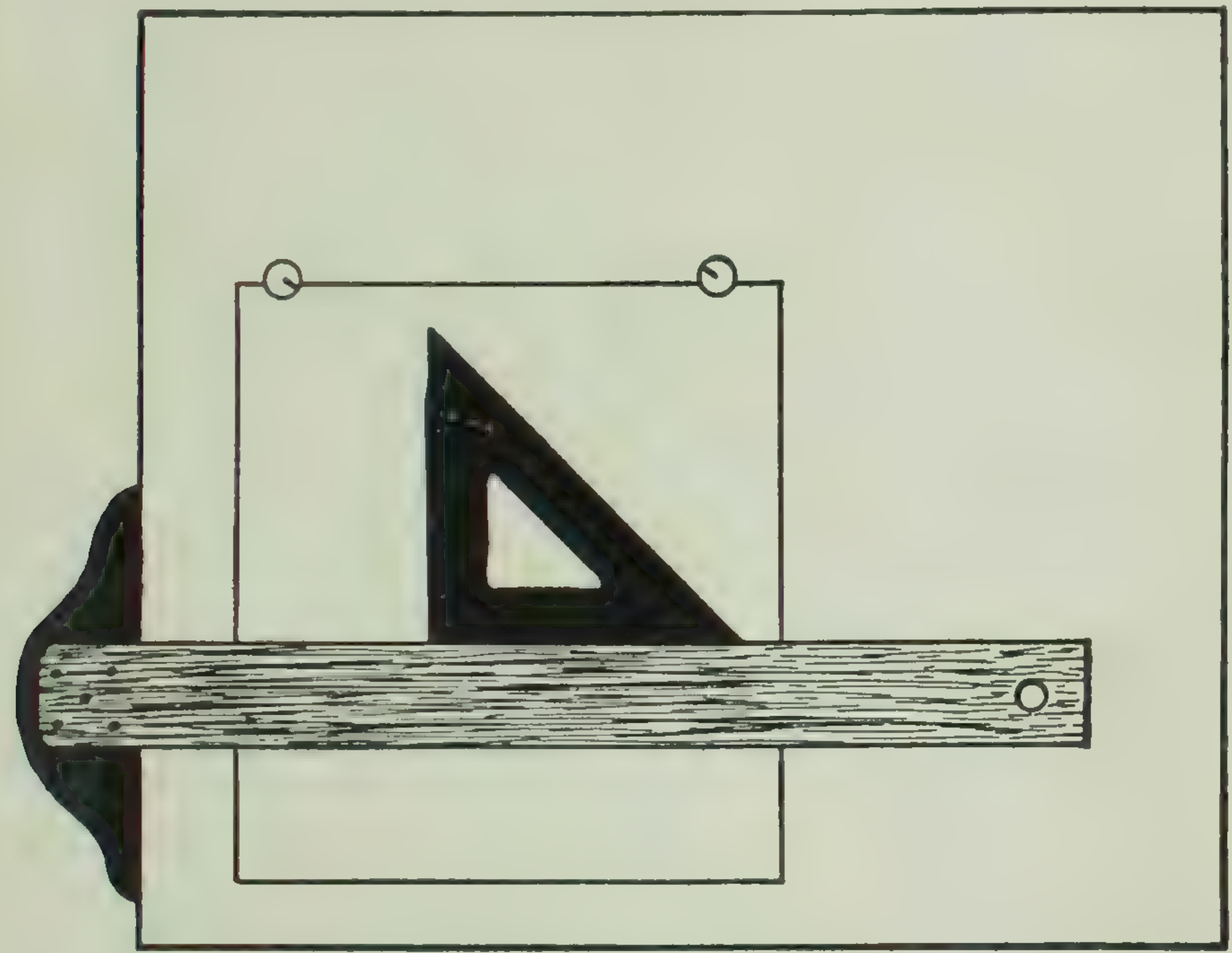

FIG. 4. DRAWING-BOARD, T-SQUARE AND TRIANGLE, SHOWING PAPER HELD IN POSITION BY THUMB-TACKS

head of the T-square is kept in a constant vertical position as it is moved up and down the left side of the drawing-board, all lines made along the ruling edge will be parallel with each other. Although the T-square may be used for general ruling purposes, its principal use is for drawing lines parallel with the base of the chart, from left to right. It may also be used for "squaring" the paper on which the drawing is made. The position of the T-square is illustrated in Figure 4.

T-squares are made in several qualities, the less expensive being

of plain wood, the better qualities being edged with ebony or celluloid. The principal test of a good T-square is the smoothness and straightness of the edge. This edge must be kept in good condition, and re-dressed or straightened if necessary.

Some T-squares are made with adjustable heads, so that they may be used for drawing slanting or diagonal lines. The principal use of such a device is in "hatching," or filling an area with parallel lines drawn at an acute angle with the base line. For ordinary purposes, however, the rigid T-square is satisfactory. The "hatching" can be done equally well with the triangle.

Triangle. The triangle is used chiefly with the T-square, as illustrated in Figure 4. The better grades are made of transparent celluloid or similar material, and in a variety of sizes and angles. The 45° type, used in the illustration, of the 6- or 8-inch size, serves most general purposes. By placing one of the short sides against the T-square, and holding both carefully in position, vertical lines may be drawn which are perpendicular to the lines ruled with the T-square. Lines drawn on the long side of the triangle will have a slant of 45° from the base.

A hasty glance at the charts in this book will reveal the preponderance of horizontal and vertical lines in charts. All of these lines were ruled with the T-square and triangle, without moving the paper. It is obviously important that the proper use of these two instruments be learned before proceeding very far in the construction of charts.

Measuring-scale. Good results in chart-making require accuracy of measurement. For this purpose the ordinary school ruler is not satisfactory. The best rulers, or scales, are manufactured especially for mechanical drawing use, and are finely graduated. The engineer's rule, in which the inches are divided decimally, is recommended for chart-making. The 12-inch size is most convenient. They are made in two styles — flat and three-cornered. The latter type contains six scales. These rules are made of smooth, hard, and well-seasoned wood, and are slightly longer than the distance they measure, so that the end marks may be accurately located. It is not necessary to use the scale for ruling lines, but only for determining the points from which and to which lines are to be drawn.

Protractor. The protractor is an instrument for measuring degrees and laying off angles. A common and useful form is made of transparent celluloid, cut in the shape of a half-circle.

(Figure 5.) Some triangles are marked for measuring degrees, and may be used as protractors. It is necessary to use the protractor in the making of circular charts in which the segments must be measured, as illustrated in Chapter V. In showing percentage comparisons, 1 % = 3.6°, 25 % = 90°, etc.

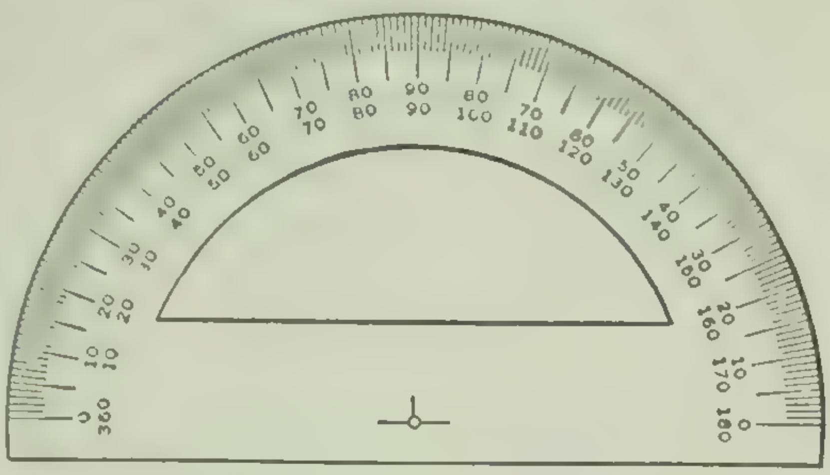

FIG. 5. PROTRACTOR, SEMICIRCULAR TYPE

Thumb-tacks. Thumb-tacks are used for fastening the paper securely to the drawing-board. If the board is of soft wood they may be pushed down tightly, and yet be easily removed. Figure 4 shows how the thumb-tacks may be used without punching through the paper. Small blocks of soft wood or cork are used as containers for thumb-tacks when not in use.

Paper. There are several good qualities of paper which are satisfactory for ink-line drawings. The charts in this book, with a few exceptions, were drawn on heavy ledger drawing paper, cut to letter-size. Another good quality is that known as *hotpressed*. It is heavier than ledger, and is especially suitable for fine-line drawings. To be suitable for this purpose, paper should have a smooth hard surface, lend itself easily to erasure, and be capable of taking ink without allowing it to absorb or spread. It should also be uniformly white, and free from breaks or creases.

Pencils. The penciling of a chart is an important but temporary procedure. The penciled lines will not show in the finished chart, and those remaining after the final inking-in should be erased. Moreover, the penciled lines must be accurate, although they need not be distinct. For these reasons a hard pencil of good quality is desired. The degree of hardness of pencils is indicated by the letter H; and H, HH, 4H, 6H, etc., represent increasing hardness. The 6H pencil is excellent for chart work, and will keep a fairly constant point if used lightly. The pencil should be sharpened to a fine long point, and it should be kept in mind that its use is but a guide for the ruling-pen, with which the lines are completed. It is desirable to acquire the habit of using the pencil very lightly, so that the final erasures will not endanger the inked portion.

Erasers. In making ink-line charts the erasing is practically limited to the removal of extra pencil marks. This is done after the drawing is completed and the ink is dry. A good quality of soft rubber, such as "Art Gum," is recommended. These erasers are made in a spongy consistency, so that particles or "crumbs" come off and roll about on the paper. This process has the advantage of cleaning the chart without affecting the ink lines, so that the entire surface may be rubbed over. Even with soft rubber, however, too much rubbing and heavy pressure on the eraser should be avoided. In view of the necessity for making erasures, all pencil work should be done as lightly as possible, and unnecessary marks avoided.

The satisfactory erasure of ink marks and blots from drawings requires skill and patience. The ink adheres so closely that injury to the surface of the paper is very likely to result from its removal. A good ink-eraser, used with a metal shield, will do for most purposes. Skillful persons may use a thin sharp knife blade. Ordinarily, erasures should not be attempted until the chart is completed and the ink is thoroughly dry. Too many erasures will spoil any chart, and suggest careless work.

If the paper is of good quality, the "cleaning-up" of the chart may be followed by rubbing the entire surface briskly with a clean dry cloth, which will remove particles of rubber and give the chart a polished appearance.

Drawing-ink. Waterproof black drawing-ink is best for general use in chart-making. This ink is heavy, and when dry becomes hard and permanent. It should be used freely and spread evenly in the lines or over surfaces which are to show black. The length of time required for drying depends upon the temperature and humidity of the atmosphere. A blotter is not used with drawing-ink. The bottles are small and flat-bottomed. The cork is attached to a pointed top, constituting the handle of a quill which is used for filling the instruments. The bottle should be kept tightly corked when not in use. If the ink becomes too thick or filled with insoluble particles it is in the interest of good results to discard it and use a fresh bottle; there is no economy in attempting to use the last few drops. Ink is highly corrosive to metallic surfaces, and should always be carefully wiped from the drawing instruments immediately after use.

Waterproof drawing-inks are also to be had in colors. They are never used for drawings which are to be reproduced in printing,

but are frequently of special advantage for making display of charts. The correct use of red and green in chart-making is explained in Chapter XVII. On the whole, black and white work is the most effective, and can be used to represent almost every set of facts.

Drawing-instruments in sets. Good instruments are essential to good drawings, and it is important that considerable care be exercised in their selection. They may be obtained in sets or singly. The sets usually come in leather cases, with convenient plush-lined receptacles for the instruments. In this form the whole set may be carried in the pocket or put away with less likelihood of being injured than if it consists of loose pieces. Most drawing sets include ruling-pen, jointed compass, dividers, bow-pen, and extra leads for the compass. Any of these instruments may be purchased separately, and, aside from the factor of care, will serve the purpose just as well. The only essential instruments for making the charts illustrated in this book are pen and compass. The dividers and bow-pen are useful, but are not needed for most simple drawings.

Ruling-pen. Ordinary steel writing-pens cannot be used for straight-line drawings, because of their unadaptability for ruling lines of uniform width. The ruling-pen (Figure 6) is a specially devised instrument consisting of a handle, usually of wood, bone, or aluminum, and a steel portion divided longitudinally into two points, or "nibs" between which the ink is placed. The nibs may be adjusted to the desired width by turning a set-screw, which is located midway between the points and the handle. The outer sides of the nibs are rounded and the points are of parabolic shape. When closed, they should be in exact alignment. So important is the condition of the nibs that if they become bent or worn so that they no longer align themselves properly, the instrument should be sharpened or re-dressed.

FIG. 6. RULING-PEN

The ruling-pen is filled, just before using, by removing the quill from the ink-bottle and inserting it between the nibs below the set-screw. The drop of ink held by the quill will adhere to the smooth inner sides of the steel nibs. The pen should be held in a vertical position, with nibs downward, so that the ink will flow toward the

points. Care should be taken to confine the ink to the inner sides of the pen, and to keep the outside portion clean and dry. After the pen is filled and the correct adjustment of the set-screw is made, it is ready for use. A single filling ordinarily suffices for drawing several lines, depending upon the size of the pen and the width of the lines drawn. If the nibs are set for wide lines there is danger of overfilling the pen, which will result in the ink running too freely. A little practice will be necessary for most persons.

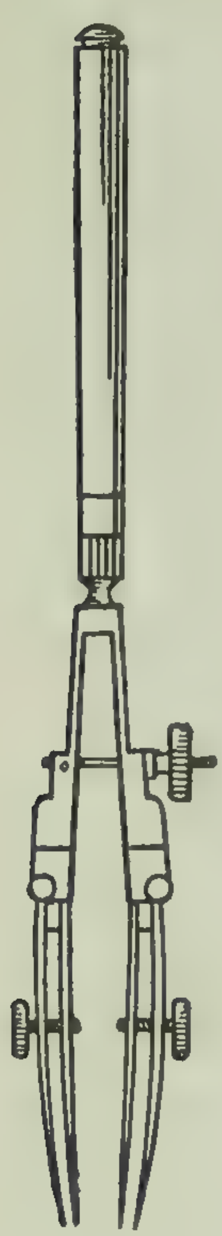

Fig. 7. Double-Ruling-Pen

It has already been stated that liquid drawing-ink is corrosive. Inasmuch as the smooth edges and surfaces of the ruling-pen are essential, every possible precaution should be taken to prevent such destruction. The ink should not be allowed to remain or to dry in the pen, but should be wiped out after every period of use. This may seem bothersome to the beginner, but any draftsman will testify to the importance of well-kept instruments.

Figure 7 illustrates the *double-ruling-pen*. This is used for making two parallel lines at a single stroke. The lines may be of equal or unequal width, and their distance apart is gauged by the large set-screw. The double-ruling-pen is not necessary for simple charts, but is useful for advanced work.

Compass. The drawing-compass differs from the ordinary school compass in that the ink end is made in the form of a ruling-pen, with adjustable nibs, so that lines of uniform width may be drawn. Compasses usually come in four parts, as illustrated in Figure 8; the main body, to which the needle point is attached; the pencil mounting; the ruling-pen; and the extension leg, which is used for making large circles.

The compass is used for drawing circles or parts of circles. The needle point is placed at the center, and the shanks separated so that the distance between the two extremities will be the desired radius. They should also be so adjusted that the lower joints of the two legs will be perpendicular to the paper. The ink is applied in the manner described for filling the ruling-pen, and the same precautions should be taken.

Bow-pen. The *bow-pen* is a small spring compass for making

very small circles. It is adjustable within a narrow range only, and is usually made entirely of steel. There is no extra leg, and the pen shank is not removable. The circles in Figures 78, 79, 85, and 86 were made with the bow-pen. The *bow-pencil* is a similar instrument for making small penciled circles.

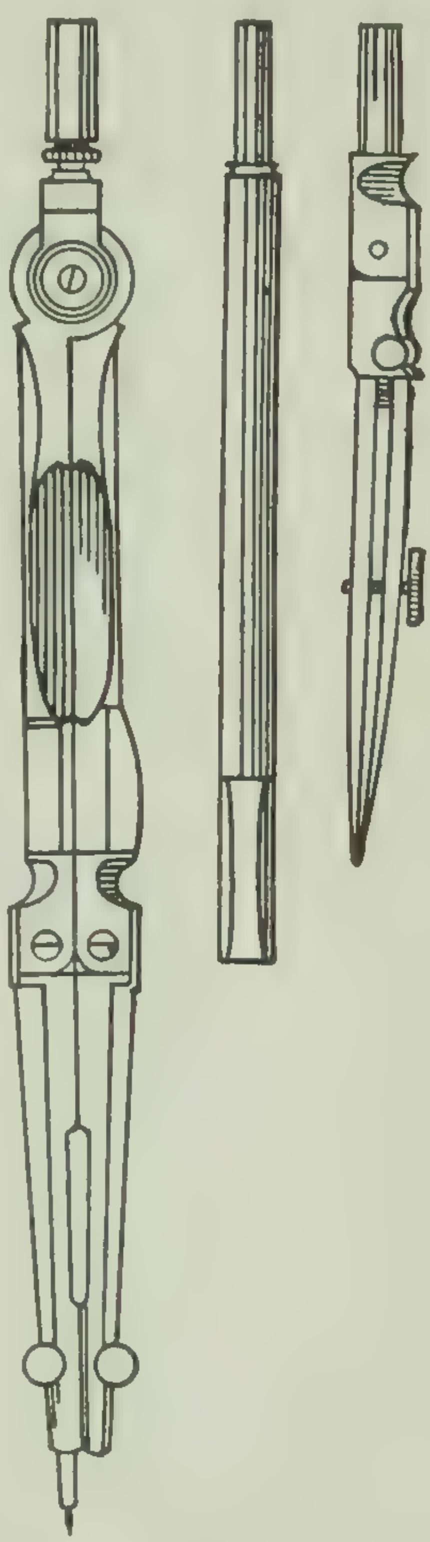

FIG. 8.
COMPASS, SHOWING PEN ATTACHMENT AND EXTENSION LEG

Dividers. This instrument (Figure 9) is used for laying off points and transferring distances from one place to another. They resemble the compass in shape and size, but the legs are not jointed. Bow-dividers, similar to the bow-pen, are useful when small spaces are being measured. By adjusting the points of the dividers to a desired distance, say 3.8 inches, as determined by the scale, the distance may be marked off on the chart by allowing the points to touch the paper where the space is to be indicated.

FIG. 9.
DIVIDERS

Lettering-pens. Many styles of lettering-pens are on the market, but any good steel pen may be used for the purpose. The size and shape of the pen is determined by the style of lettering, the size of the letters, and the individual preference of the user. Ball-pointed pens lend themselves to uniformity, and are usually recommended for beginners; they need not be used exclusively, however, and many persons will prefer a finer point. The choice of pen can be determined only through individual experiment. Steel pens corrode easily, and should be kept dry and clean. It is good economy to use a fresh pen whenever one in use shows signs of wear or injury. The pen should be used in a good pen-holder, which should also

be chosen carefully, according to the user's experience. Cork holders are usually satisfactory.

Among the special types of lettering-pens may be mentioned the Payzant pen, which makes a uniform width of line regardless of the pressure exerted upon it, and which contains a reservoir from which the ink flows continuously. These pens are made in several sizes, and are sometimes used for ruling as well as lettering. Draftsmen frequently prefer such pens for extensive lettering-jobs.

2. *Practice sheets*

Complete directions are given here for the construction of five practice charts. These lessons are prepared especially for persons who desire to make charts, but who have not had the advantage of a course in mechanical drawing. It is not presumed, of course, that five single lessons will give the beginner the equivalent of such a training course; but it is believed that any one who can successfully prepare the five practice charts can do satisfactory work in making most of the types of charts represented in this book. Native ability, interest, experience, maturity, and perseverance are among the factors which determine the quality of charts, and these traits occur with a wide range of individual differences.

PRACTICE SHEET NUMBER 1. HORIZONTAL AND VERTICAL RULING

(Illustrated in Figure 10)

MATERIALS NEEDED: Drawing-board; T-square; triangle; ruling-pen; 2 thumb-tacks; sheet of paper, $8\frac{1}{2} \times 11$ inches; measuring-scale; pencil; eraser; black drawing-ink.

1. Placing the paper. Place the paper near the lower left-hand corner of the board, as in Figure 4. See that it is as nearly square with the board as possible. Then, with the aid of the T-square, held firmly to the left edge of the board, complete the squaring process. Now fasten the paper securely with two thumb-tacks, as shown in the illustration. Do not push the tacks through the paper, but insert their points in the board just above the top of the sheet, pushing them down until the paper is held under their projecting heads. When the sheet is securely fixed, test it again with the T-square for straightness, and proceed with the next step.

2. Measuring the spaces. With the T-square and pencil, lightly draw a horizontal line 1 inch below the top of the sheet, and extending its full width. Find the center of the line, and indicate by a point. Now lay off a line 7 inches in length, by marking a point in each direction 3.5 inches from the center. These points will be considered the extremities of the line.

With the triangle in position on the T-square (observe Figure 4), drop a vertical line 4.5 inches in length from each of the extremities of the 7-inch line. Now, measure off, along the *left* vertical line, a series of points exactly one half inch apart. Counting the beginning of the top line, there will be 10 of these points.

3. Penciling the lines. Again fixing the T-square in position, draw a light pencil line from each of the points to the opposite vertical line. You will now have a rectangle 7×4.5 inches in size, ruled with 10 horizontal lines.

Using the T-square and the triangle as a guide, lay off a horizontal 7-inch line exactly one half inch below the lower line of the rectangle just drawn, with its extremities exactly below, and in line with, the extremities of the horizontal lines in the rectangle just completed. From this line construct another rectangle of

the same dimensions. It will extend to within approximately one half inch from the lower edge of the paper.[1]

Along the base of the lower rectangle lay off a series of points one half inch apart, and (in pencil) rule a series of vertical lines extending to the upper side. Counting the end boundaries there will be 15 vertical lines.

4. *Inking-in the lines.* Now set the ruling-pen for a line of medium width, and, using the T-square for a guide, ink-in the 10 horizontal lines, beginning at the top. If the pen is properly filled and the work is quickly done, one filling should be sufficient for at least five lines. When the ink becomes low, however, refill the pen at once, and do not begin a line without making sure that there is enough ink in the pen to complete it. If any difficulty is experienced in handling the pen or drawing lines, the need for more practice is indicated.

After the horizontal lines are dry, ink-in the 15 vertical lines in the lower rectangle, using the edge of the triangle, held in position on the T-square. This is more difficult and requires more patience than making horizontal lines, but it can be mastered with practice.

5. *Cleaning the chart.* After all ink lines are dry, use a soft rubber eraser to remove the visible pencil marks. The lines which represent the permanent portion of the chart will have been covered with ink. In using the eraser, care should be taken to avoid wrinkling the paper or dulling the ink lines by exerting too much pressure.

6. *General observations.* The appearance and accuracy of Practice Sheet Number 1, and the ease with which it is drawn, will indicate in a general way the extent to which one may feel ready to undertake the subsequent exercises. It would be unusual for a beginner, unaccustomed to the handling of instruments, to make this chart without considerable difficulty, or without spoiling at least two sheets in the course of the exercise. Among the errors in technique which may be experienced are the following:

(*a*) *Slipping of the paper*, due to insecure fastening with thumb-tacks. If the paper slips after the first line is drawn, it is necessary to square it again, using the first line as a guide. Otherwise the subsequent lines will not be parallel to it, and the rectangular areas will not be true.

(*b*) *Incorrect spacing*, due to failure to indicate points on the paper exactly

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[1] Paper is rarely cut to exact measurements, and the corners are seldom exactly square. It should never be relied upon with respect to these matters, but measurements should be made separately for each chart.

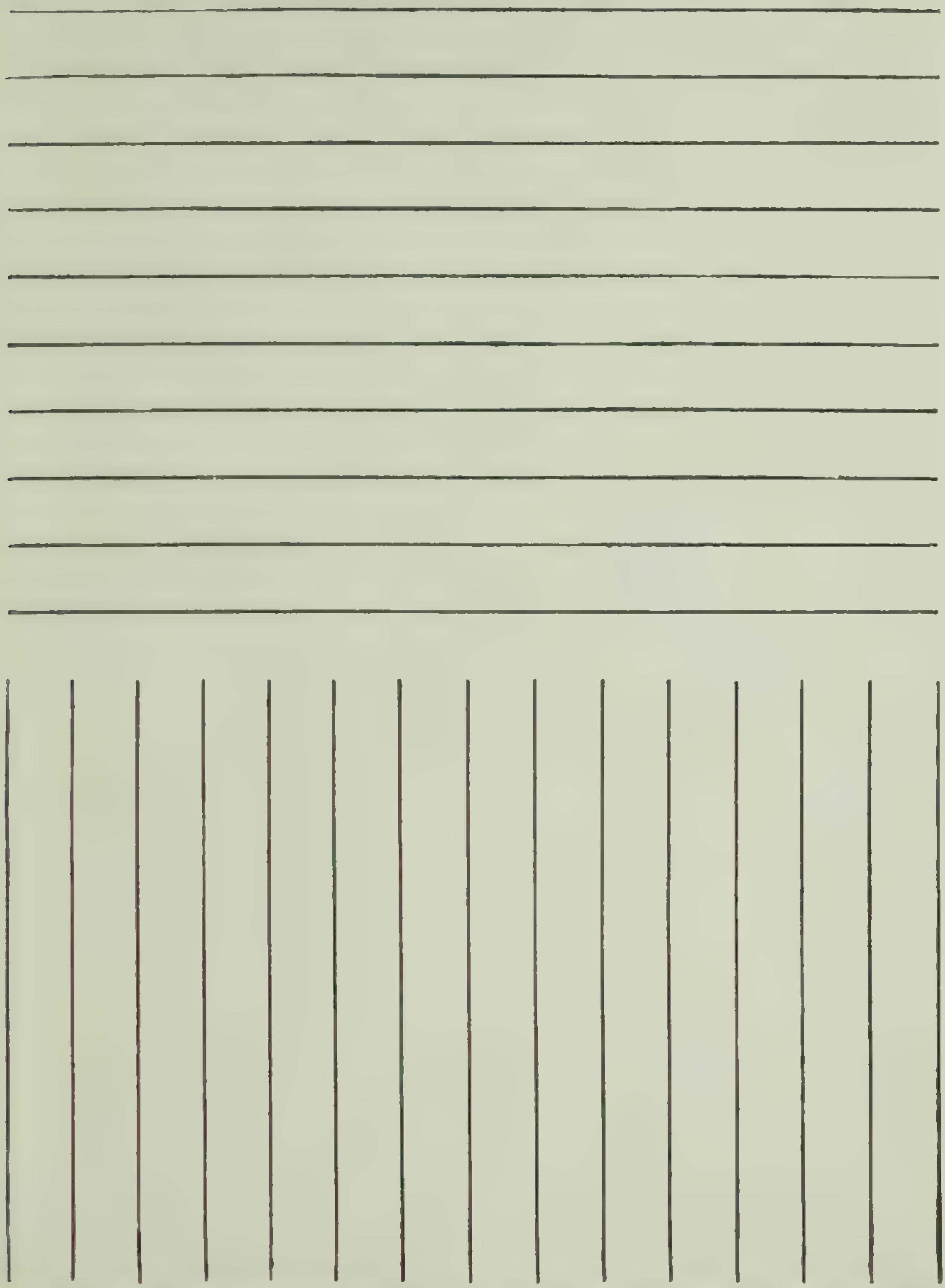


Fig. 10. Practice Sheet Number 1. Horizontal and Vertical Ruling

where they occur on the measuring scale. A very sharp pencil, used with care, is the answer to the difficulty. A good chart cannot be drawn with points only approximately located.

(*c*) *Too much pressure in penciling*, increasing the difficulty of erasing. It should be constantly in mind that pencil marks are guides only, and that they do not form a part of the permanent chart. Very light lines require less effort, serve the purpose well, and necessitate less frequent sharpening of the pencil.

(*d*) *Blotching of lines*, due to faulty position of ruling-pen or ruling-edge. If the ink is allowed to touch the T-square or triangle when ruling, or before the line is dry, a flow of ink is started which spreads under the edge and ruins the line. Blotches of this kind cannot easily be removed, and their occurrence in a practice chart should be sufficient reason for beginning a new sheet. The pen should be so held that both nibs touch the paper with equal pressure, and with the handle slightly inclined in the direction of the line. The side containing the set-screw is faced away from the ruling edge. After the line is drawn the ruling instrument (T-square or triangle) should be lifted off the paper, or moved away from the fresh ink.

(*e*) *Unevenness in thickness of lines*, due to pressing the pen too strongly at times against the ruling edge. The amount of pressure necessary to guide the pen is very little.

(*f*) *Roughness of lines*, due to unequal pressure on the nibs, or leaning the pen toward one side. The lifted side will leave a jagged edge.

(*g*) *Unevenness in length of lines*, due to failure to begin and end lines at the penciled extremities. Practice in putting down and lifting the pen will help overcome this difficulty.

(*h*) *Incomplete inking of lines*, due to failure to observe, before beginning a line, whether sufficient ink is in the pen for its completion. A skillful draftsman can reconstruct a line thus broken, but it is a difficult task for a beginner. It is far better to avoid the error by watching the supply of ink in the pen. It is well to learn as soon as possible the correct level at which the ink can most successfully be retained.

PRACTICE SHEET NUMBER 2. RULING CONTINUOUS AND BROKEN LINES

(Illustrated in Figure 11)

MATERIALS NEEDED: Same as for previous exercise.

1. Placing the paper. Follow directions given for Practice Sheet Number 1.

2. Measuring the spaces. Lay off, in pencil, a 7-inch horizontal line, centered on the paper as in the previous exercise. From each extremity of the line, with the aid of the triangle, drop a perpendicular penciled line to the bottom of the sheet. Along the left line measure and place 23 points exactly .4 inch apart, beginning at the upper horizontal line at the top. With the T-square, rule a light penciled line from each of these points. Counting the top line there will be 24 in all.

3. Inking-in the lines. (*a*) Set the ruling-pen for a line of *medium* thickness, and ink-in the first two lines, as in Practice Sheet Number 1. These lines are *continuous*. (*b*) Rule two *dash* lines, as in Figure 11. The length of the dashes and spacing of intervals is determined by the eye alone, and uniformity can be obtained only through practice. (*c*) Rule two *dot* lines, as in the illustration. The "dots" are really short dashes, and each should be drawn as a line. Round dots cannot be made uniformly with the ruling pen, and should not be attempted for this purpose. (*d*) Draw two *dash-dot* lines, as in the illustration.

Beginning at the ninth line, set the ruling-pen for a *heavy* line, and draw: (*a*) two continuous lines; (*b*) two dash lines; (*c*) two dot lines; (*d*) two dash-dot lines.

Beginning at the seventeenth line, set the pen for a *fine* line, and repeat the sequence of the foregoing.

In determining the width of the fine line a few trial lines should be made on extra paper. Fine lines are more difficult to draw than medium or heavy lines. When the nibs are very close together the ink forms a thin film in passing through, and frequently hardens, stopping the flow even when the pen is well filled. At times the point will be clogged by particles of dust or fiber, suspended in the ink or collected from the paper. In either case it is necessary to clean the pen by passing a small strip of paper or thin celluloid between the nibs, and, if necessary, refilling the pen. In view of these difficulties the beginner should not attempt too

fine a line. Extremely fine lines are seldom necessary in chart-making, and their use is advised against for charts which are to be reproduced, because they often fail to show in the line etching.

4. *Cleaning the chart.* Follow instructions for the previous exercise.

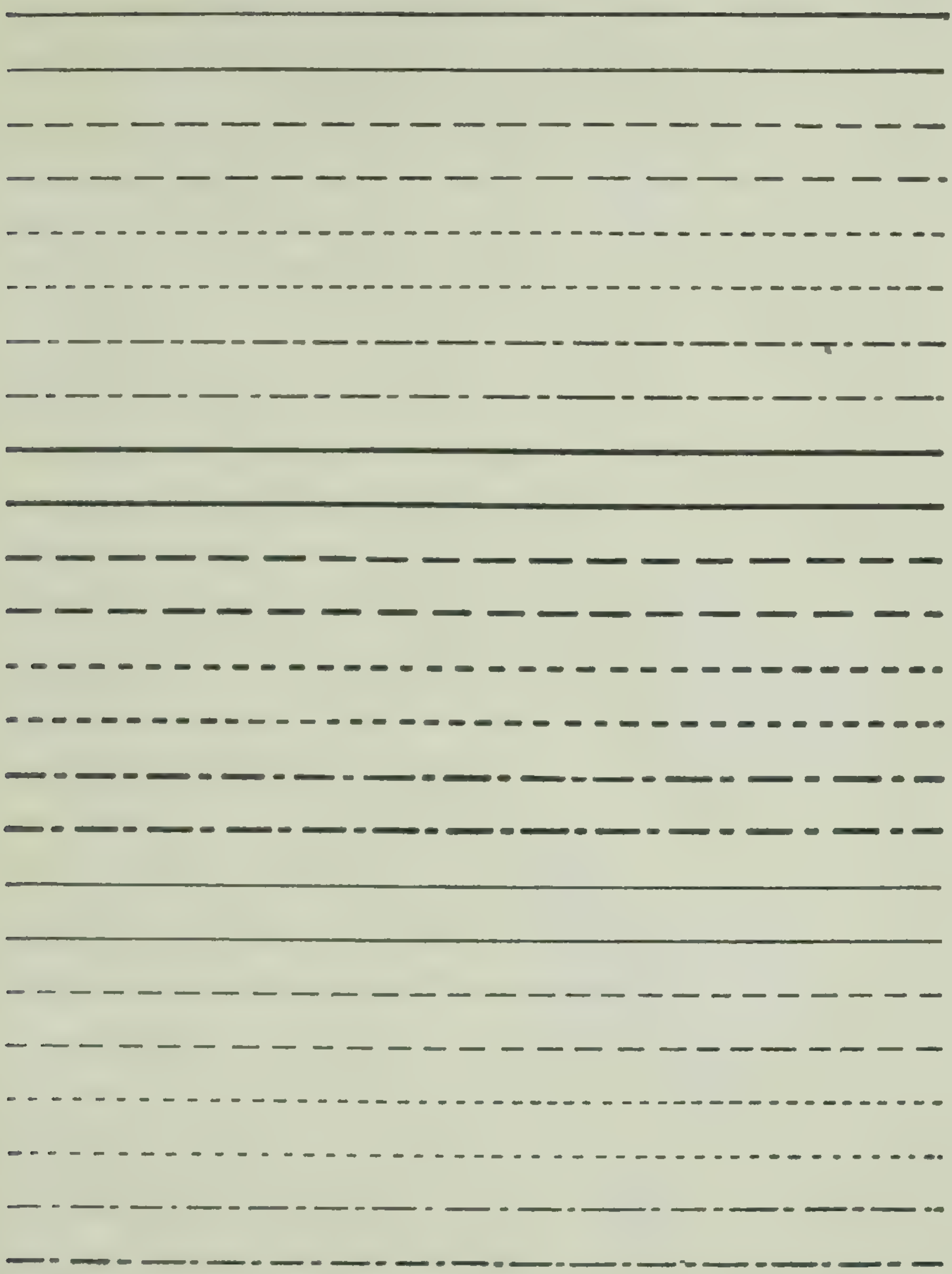


Fig. 11. Practice Sheet Number 2. Ruling Continuous and Broken Lines

PRACTICE SHEET NUMBER 3. SINGLE- AND DOUBLE-HATCHING

(Illustrated in Figure 12)

Materials Needed: Same as for previous exercises.

1. Placing the paper. Follow previous instructions.

2. Measuring the spaces. Lay off two rectangles, each 7 × 4 inches, and one-half inch apart. They should be centered horizontally on the paper. Draw a diagonal penciled line across the upper rectangle, from the upper left to the lower right corner. Along this diagonal lay off points exactly .2 inch apart. With the triangle placed on the T-square with its hypothenuse toward the left, draw a penciled line slanting upward through each of these points, extending at either end to the boundary it happens to strike. These lines will be parallel, and will have a 45° slant. This is called *single-hatching.* Its use is illustrated in Figures 24, 25, and 26.

In the lower rectangle lay off two intersecting diagonals, and lay off similar points on each. Pencil two series of slant lines, each having a 45° slant, but intersecting at right angles. This is called *double-hatching.* Its use is illustrated in Figures 21 and 26.

3. Inking-in the lines. Set the ruling-pen for a line of medium thickness, and ink-in the *borders* of the two rectangles. When the borders are dry, set the pen for a *slightly thinner* line and ink-in the slant lines. Use the T-square and triangle exactly as when the lines were penciled, and maintain uniformity of procedure throughout. *Do not* ink-in the diagonal on which the points were laid off in the upper rectangle.

4. Cleaning the chart. Follow previous instructions.

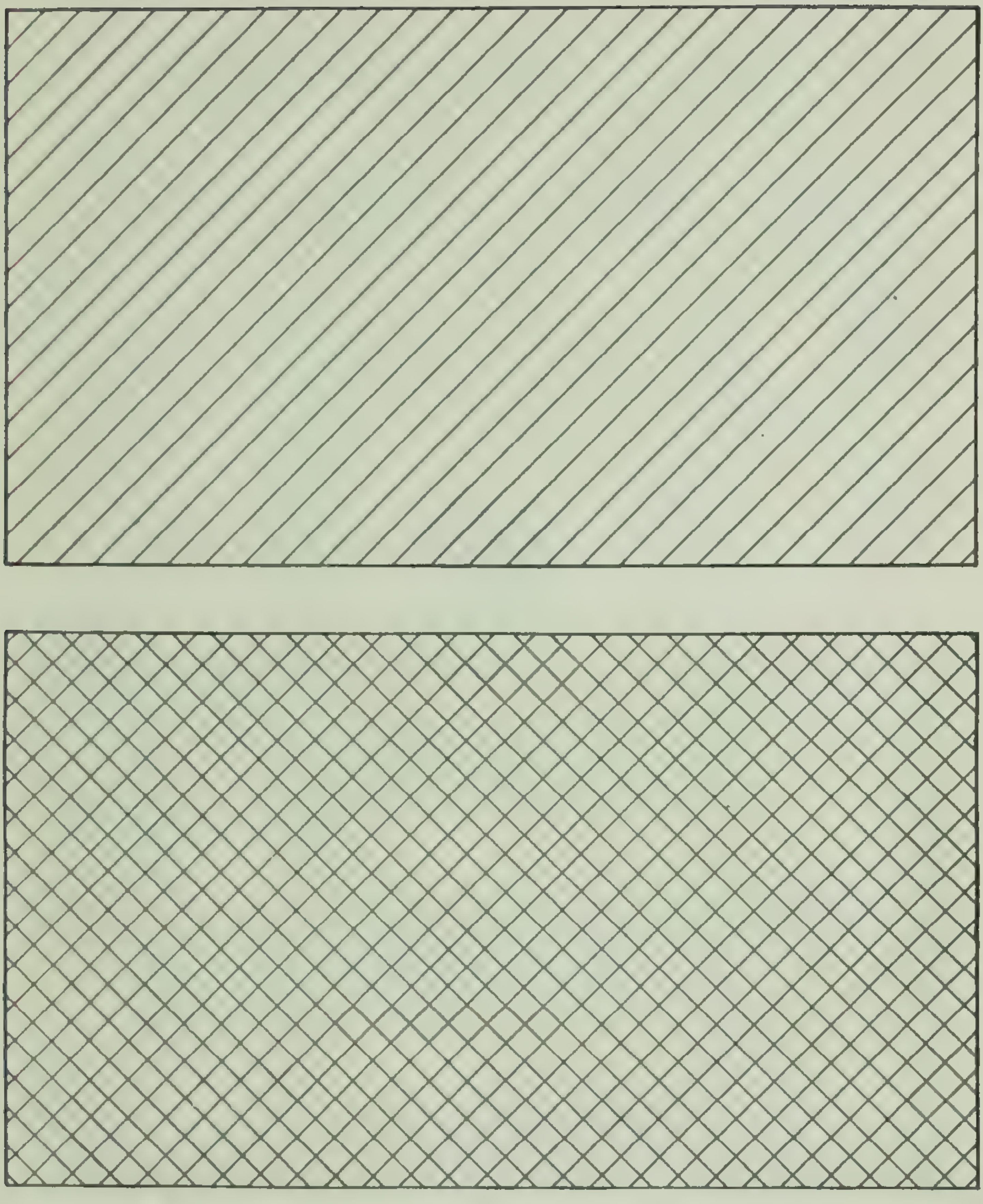


FIG. 12. PRACTICE SHEET NUMBER 3. SINGLE AND DOUBLE HATCHING

PRACTICE SHEET NUMBER 4. INKED-IN AREAS

(Illustrated in Figure 13)

Materials Needed: Same as for previous exercises.

1. *Placing the paper.* Follow previous instructions.

2. *Measuring the spaces.* Lay off a 6-inch square, the top of which will be 2 inches from the top of the paper. Inside of this, lay off a 5-inch square, exactly centered. Lay off additional squares, 4 inches, 3 inches, 2 inches, and 1 inch in size, making sure that they are accurately measured and spaced.

3. *Inking-in the lines.* With the ruling-pen set for a medium line, ink-in the six squares just constructed. Make sure that the corners are neat and correct.

4. *Cleaning the chart.* After the six squares are drawn, and the ink is dry, erase the superfluous pencil marks. Note, however, that *the chart is not yet completed.* The inking-in of areas should be the final operation, even following the erasing and cleaning. Erasers should not be rubbed over these areas.

5. *Inking-in the areas.* Beginning with the center square, ink-in the alternate areas, as shown in Figure 13. The inking can be done with the edge of the ruling-pen, with a broad lettering-pen, or a small brush. The important part of this task is to spread the ink evenly over the surface without crossing the boundaries. The ink should be used freely, until the areas indicated are solid black.

It will require some time for this chart to dry, so it should be laid away carefully and in a flat position.

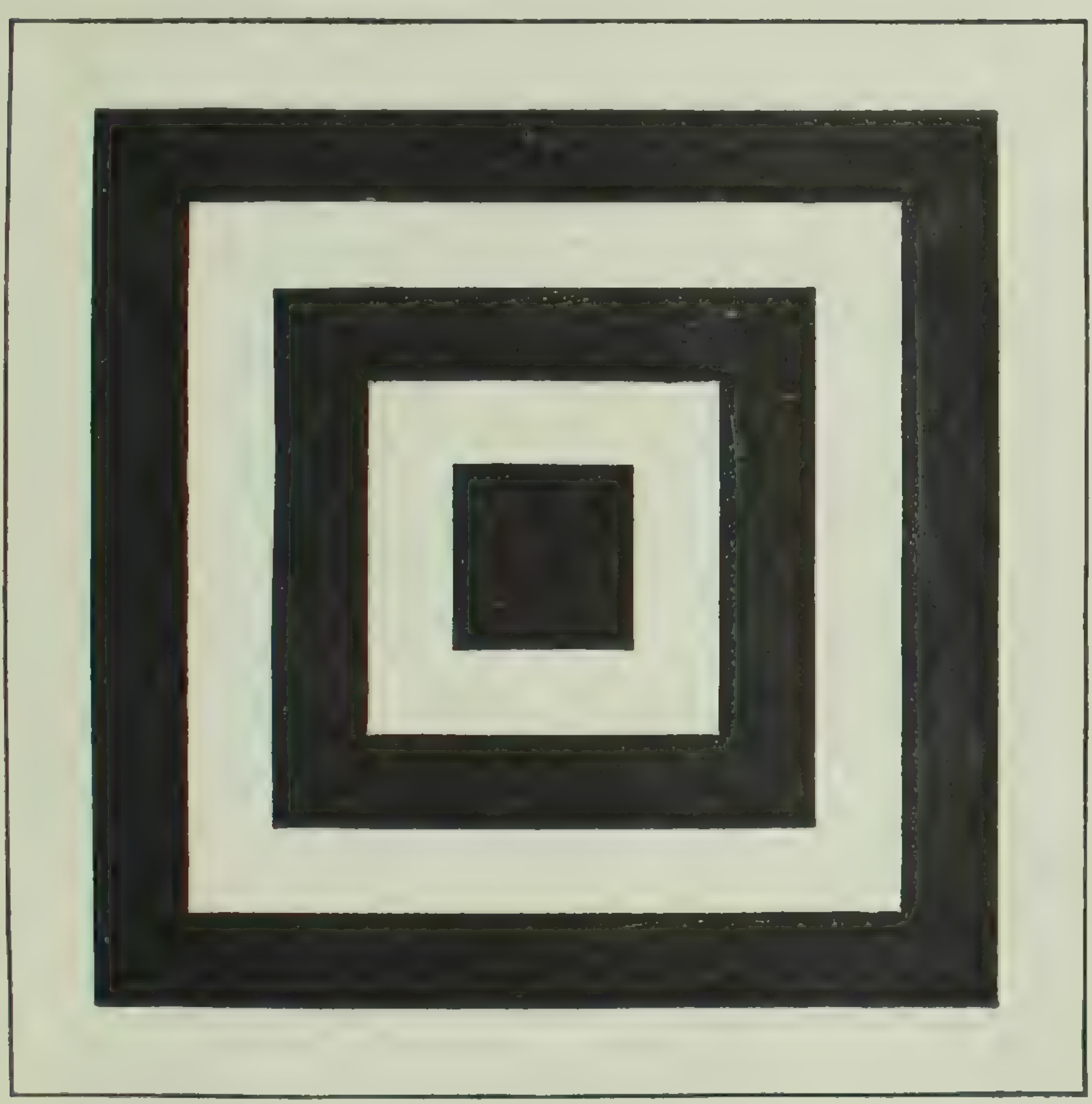


FIG. 13. PRACTICE SHEET NUMBER 4. INKED-IN AREAS

PRACTICE SHEET NUMBER 5. CIRCLES

(Illustrated in Figure 14)

MATERIALS NEEDED: Same as for previous exercises.

1. *Placing the paper.* Follow previous instructions.

2. *Measuring the spaces.* Draw a horizontal line across the paper 5 inches from the top. At the mid point of this line draw a perpendicular line extending 3 inches upward. Lay off points on the vertical line one-half inch apart. There will be six points in all, counting the intersection of the lines.

3. *Inking-in the lines.* It is not necessary to draw the circles in pencil lines, inasmuch as the compass is automatically guided from a single point. Set the compass so that its needle is at the intersection and its ruling-points are at the dot one-half inch above it. Adjust the nibs for a *fine* line, and draw a circle. Now spread the compass until it reaches the next point, bending the legs to keep both ends perpendicular to the paper. Set the nibs for a *slightly heavier* line and draw the second circle. Continue with circles 3, 4, 5, and 6, increasing the thickness of line for each.

The amount of pressure exerted on the compass should be just enough to hold it in its place, and to guide the pen around the circumference. Pressing heavily upon the needle thrusts it through the drawing-board, with resulting danger of injury to the instrument and inaccuracy in drawing. Expert draftsmen often draw circles without penetrating the paper.

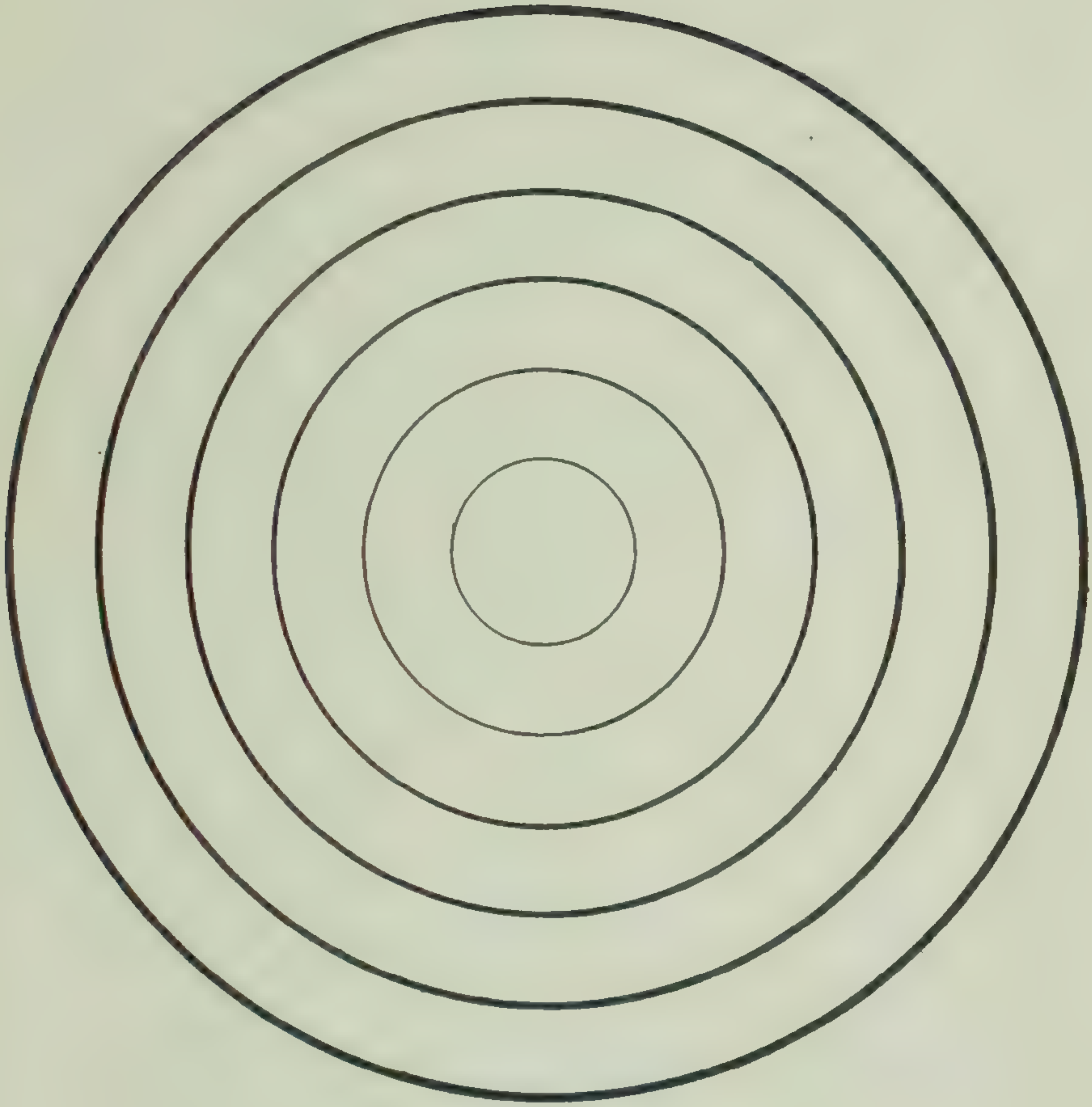


FIG. 14. PRACTICE SHEET NUMBER 5. CIRCLES

3. Lettering

Importance of lettering. Most charts consist of lines and areas, with explanatory words or numbers. The aim of chart-making is to have the facts told by the drawing, but it is not often that the drawing alone will suffice. It must be accompanied by words and numerical scales or data. The effectiveness and accuracy with which this part of the work is done helps to determine the value of the chart.

Equipment for lettering. The type of lettering with which we are concerned here is designated *free-hand*, which means that it is done with independent strokes guided by the eye. It is thus distinguished from lettering in which each letter is separately measured and ruled off by the use of mechanical guides. The necessary equipment includes pencil, lettering-pen, and ink. The parallel horizontal guide-lines on which the letters are made are ruled lightly with pencil, with the aid of the T-square. The *lettering-angle*, a small triangle punched with holes, may be used for laying off the lines, but it is not essential.

Practice in lettering. Special lettering-books are obtainable, which resemble the "copy-books" formerly used in schools for penmanship lessons. These are ruled off in the correct manner, and contain models from which the letters may be constructed. It is recommended that the beginner provide himself with one of these books, and through its use become familiar with the technique of lettering. The methods of instruction vary, but all are based on the premise that the chief element in the mastery of lettering is *practice*.

One instruction system begins with the straight-line letters, the simplest of which is I. Then follow T, L, H, F, E, N, Z, etc., and their use in words made up exclusively of straight letters, such as ELEVEN, FIFTEEN, HAVANA, KYANIZE, INFANT, LITTLE, MANY, NAME, TALENT, VALENTINE, WHITE. The next step is the construction of round letters; O, Q, C, G, S; then combination letters; B, J, P, R, U. The numerals, 1 2 3 4 5 6 7 8 9 0, are learned through similar practice.

Style and form of letters. A page of free-hand lettering is shown in Figure 15. These are the simpler forms, selected from a large number which have been devised. Lettering has become a special branch of art, and skilled penmen have adapted it to a

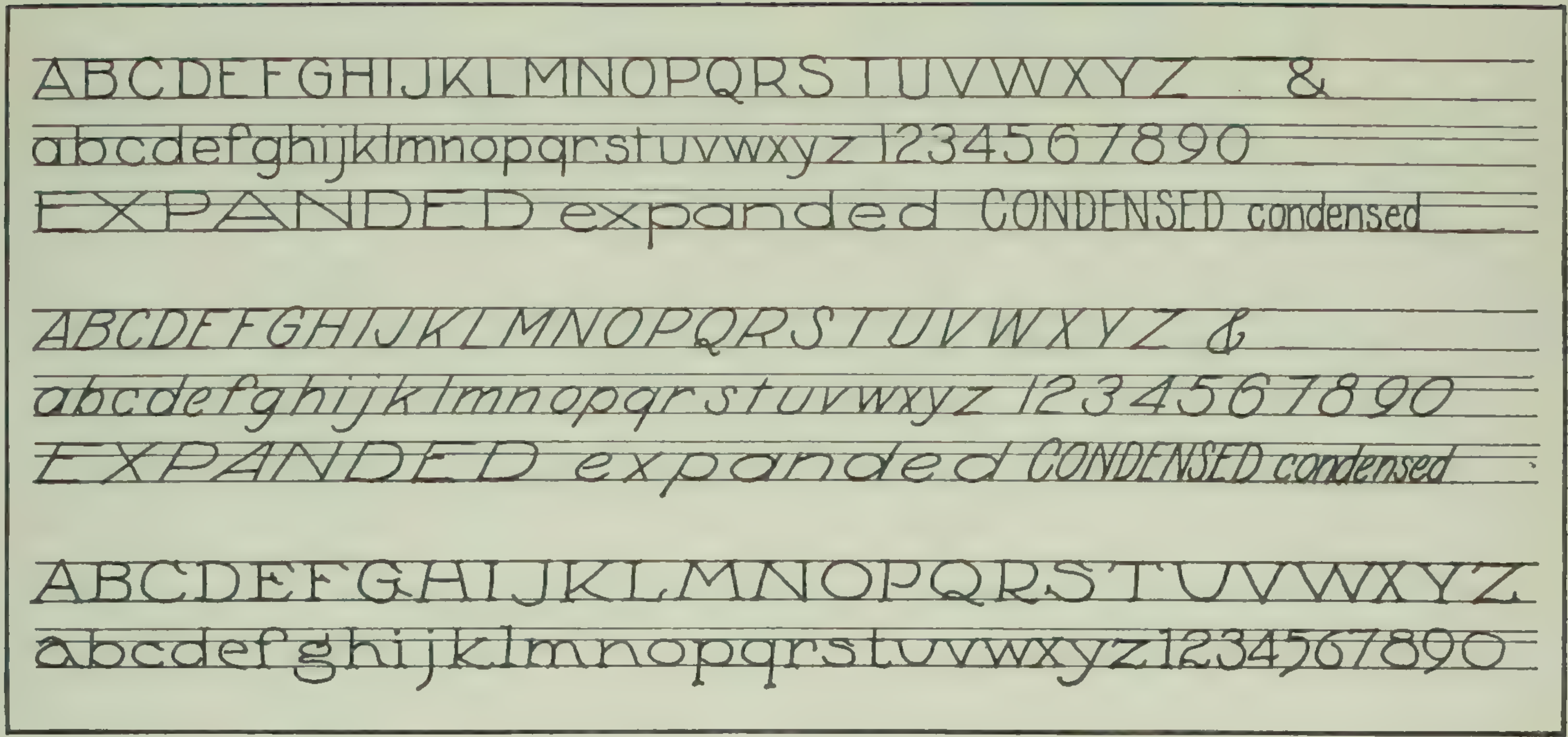


FIG. 15. SAMPLES OF FREE-HAND LETTERING

multitude of uses. There are, in fact, styles of lettering to suit every conceivable taste. The forms shown in Figure 15 include the following: (*a*) vertical; (*b*) slant; (*c*) display lettering for large charts. All three of the sections shown in Figure 15 were lettered with a small size ball-pointed steel pen, which is recommended for general lettering use.

In the two upper sections the ruling has been retained for illustrative purposes, although in actual practice these lines are ruled in pencil and erased after the ink is dry. Capitals are constructed between two parallel lines, ruled according to desired height of the letters. Lower-case letters are three fifths the height of capitals, and are constructed with the aid of three lines. These lines, accurately spaced, are easily ruled with the lettering-angle, which is slid along the edge of the T-square while the pencil point projects through the holes. If a lettering-angle is not available, the spacing is measured and laid off on the left side of the paper by means of fine points, from which the lines are drawn along the T-square. The points are marked in groups of three, at distances 0, 3, and 5.

In lettering charts it is usually advisable to do the work first in pencil. This serves to determine the correct spacing of words, and permits an inspection of the work before the inking is begun. Pencil marks are easily erased, so that the lettering may be repeated any number of times necessary to suit the requirements of the chart. When the work is satisfactory, the letters may be inked-in over the penciled forms, usually with some improvement in shape and accuracy.

There is no single size of lettering or numbering which is applicable to all charts. Probably three sizes, however, will serve for nearly all chart purposes. It is well to adopt such a series, and to use it exclusively for ordinary work. The choice of size is chiefly a matter of proportion and legibility. Lettering too large or too small may spoil the appearance or usefulness of an otherwise correctly-drawn chart. Sense of proportion and attentiveness to detail are traits which contribute much toward successful work.

Paragraph for practice lettering. The following paragraph, from the text by Professor J. C. L. Fish, is excellent copy for practice:

All the strokes of each letter should be of the same width. It is a good plan to practice drawing straight lines slowly, and with constant pen pressure till lines can be made as uniform in width as those drawn with the ruling-pen. It will be found that even an unsteady hand can make fair lines after a little practice. Steady the pen if necessary by holding the left hand on the paper with the left first finger extended and pressed against the right thumb nail. Rapid strokes are smoother but cannot usually be controlled to correctly form letters.

The measurement of lettering. A scale for measuring the quality of free-hand lettering has been devised and standardized by Professor H. O. Rugg. The score-sheet, on which the gradings are made, contains eight specimens of lettering, of gradually increasing degrees of perfection, selected from the work of a number of students in lettering classes. The eight steps on the scale have been assigned values of 30, 40, 50, 60, 70, 80, 90, and 100, respectively. These values were derived by inspecting the samples and checking for defects in the following elements: (*a*) uniformity in height of letters; (*b*) spacing between letters and words; (*c*) stems, or straight-line portions of letters; and (*d*) ovals, or rounded parts.

The scale may be used in the same manner as the Thorndike and Ayres scales for handwriting. The specimen to be measured is compared with the samples on the standard score-sheet, and assigned a value according to the step to which it most nearly corresponds in quality. The highest step on the score-sheet may

be used as a pattern for the student of lettering. A quality of at least 80 should be attained for good chart-making.

The Rugg scale is reproduced in Daniel Starch's *Educational Measurements*, page 170.

SELECTED REFERENCES

Bennett. *Problems in Mechanical Drawing.* Peoria: Manual Arts Press.

Evans. *Effective Methods in Mechanical Drawing.* Peoria: Manual Arts Press.

Fish, J. C. L. *Linear Drawing and Lettering.* New York: McGraw-Hill Book Company, 1915. Pp. 65.

Fish, J. C. L. *Blank Book for Lettering.* New York: McGraw-Hill Book Company.

Fox, W., and Thomas, C. W. *A Practical Course in Mechanical Drawing.* New York: D. Van Nostrand Company, 1920. Pp. 98.

French, Thomas E. *Mechanical Drawing.* New York: McGraw-Hill Book Company, 1918. Pp. 399.

French, Thomas E. *A Manual of Engineering Drawing for Students and Draftsmen.* New York: McGraw-Hill Book Company, 1918. Pp. 319. (See especially chapters II and III, on the "Selection and Use of Instruments.")

French, Thomas E., and Turnbull, C. E. *Lessons in Lettering.* (Book 1. *Vertical Single Stroke.*) New York: McGraw-Hill Book Company, 1921. Pp. 40.

French, Thomas E., and Turnbull, C. E. *Lessons in Lettering.* (Book 2. *Inclined Single Stroke.*) New York: McGraw-Hill Book Company, 1921. Pp. 40.

Kenison, E., and Waite, E. B. *Mechanical Drawing.* Chicago: American Technical Society, 1920. Pp. 143.

Leeds, Chas. C. *Mechanical Drawing for Industrial and High Schools.* (39 lessons.) New York: D. Van Nostrand Company. Pp. 92, illustrated.

Ludwig, Frank. *Essentials of Mechanical Drafting.* Springfield: Milton Bradley Company, 1917. Pp. 132.

Miller, H. W. *Mechanical Drafting.* Peoria: Manual Arts Press, 1915. Pp. 225.

Reinhardt, Chas. W. *Lettering for Draftsmen, Engineers and Students.* New York: D. Van Nostrand Company, 1920. Pp. 39.

Rollinson, Charles. *Alphabets and Other Material Useful to Letterers.* New York: D. Van Nostrand Company. Pp. 33.

Rugg, Harold O. "A Scale for Measuring Free-hand Lettering"; in *Journal of Education Psychology*, VI, 1915, pp. 25–42.

Stevens, Thomas W. *Lettering.* New York: Prang Company, 1916. Pp. 127.

Svensen, Carl L. *Essentials of Drafting.* New York: D. Van Nostrand Company. Pp. 200.

Warne, Frank J. *Chartography in Ten Lessons.* Washington: Published by the Author, 1919. Pp. 159. A set of ten pamphlets.

CHAPTER III

SQUARES AND SIMPLE AREAS

Explaining Figures 16 to 26, Inclusive

General definition. The charts shown in this chapter are of the simplest type in common use. Simplicity characterizes both their data and structural form. They increase in complexity as we approach the end of the chapter, but the same principle is applied in all — the use of a simple area, such as a square, triangle, or rectangle, for representing a given value. It will be observed that all of the charts of this type are comparative; that is, one fact, or set of facts, is shown in relation to another. It is with relative values that chart-making is almost entirely concerned.

Adjacent squares. Figure 16 shows two squares placed side by side in order that we may compare the farm products of one year with those of another. The smaller square represents $89,282,158, and is measured according to a scale determined according to the amount of space to be devoted to the drawing. The large square, representing $172,316,862, is constructed according to the same scale, so that the areas of the two will correctly represent the given values. The squares are placed on the same base line, which, however, is not shown in the drawing, for it would tend to mislead. The comparison is based solely upon the *areas* of the squares, not their *heights*.

This is not always clear to the reader, and unless it is made so through some special explanation, such a chart should not be used. It is easier to make mental comparisons of height than of area. Inasmuch as $172,316,862 is nearly twice the value $89,282,156, the area of the larger square is nearly twice that of the smaller. In height, because of the ratio obtaining between numbers and their square roots, the proportion is quite different, the larger square being only about one sixth taller. It would be better, for this reason, to avoid the use of squares and to use rectangles of equal bases, as is illustrated in Figure 41. It should be noted that numerals representing the exact amounts and the dates are plainly indicated on the chart. This is a rule that should be generally followed.

Figure 16 represents a type of chart which is very commonly used, although, for the reasons explained above, it is not a suitable method of comparison. It is important for beginners in chart-making to understand the basis upon which charts may be judged, and hence the use of this illustration. One of the problems at the end of this chapter asks for the reconstruction of this chart along standard lines.

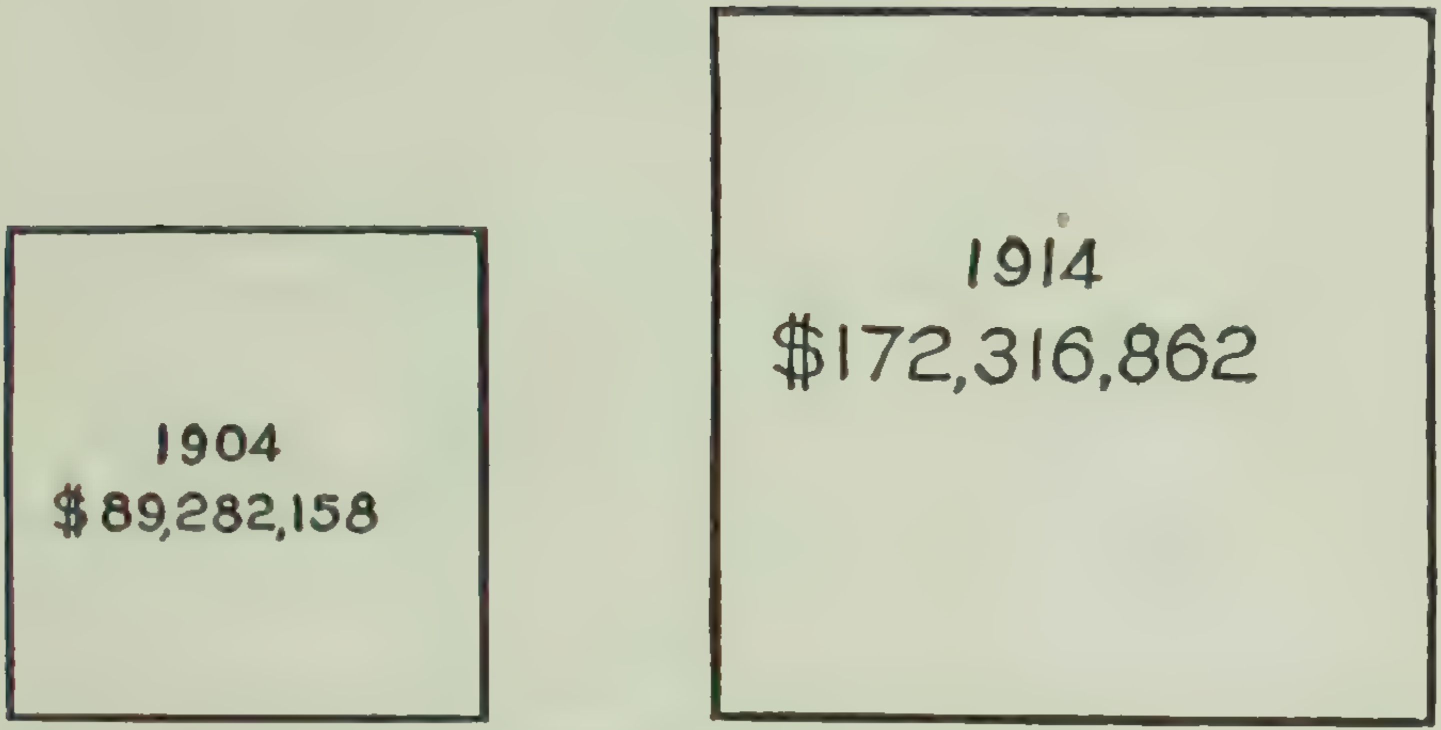


Fig. 16. Farm Crops of a Western State Showing the Increase in Ten Years

Superimposed squares. The same squares shown in Figure 16 are reproduced in Figure 17, with the smaller square placed upon the larger. A better idea of the relative areas can be obtained in this way, and the idea of *growth*, which is the principal idea in the chart, is more readily grasped because the actual difference in the size of the two areas in seen in relation to both values. The upper and right-hand portion, of inverted L shape, represents a value of $83,034,704, which is the increase for the ten years. The shape of this part, however, is not suitable for ready visual comparison with the squares, and hence much of the desired impression is lost. Another misleading feature is the fact that in superimposed areas, only a part of the larger one can be shown. Some persons are likely to think that the upper figures are represented by the portion not included in the smaller square, instead of mentally reconstructing the missing part.

Figure 18 shows a smaller square placed inside, and entirely free from the larger. This is better from the standpoint of the source of error just noted, but the actual difference between the two values is not so clearly indicated. In this instance the difference in size is so great that one would be less apt to think of the value of the larger square being only that portion not included in the smaller. It should also be noted that in this instance the comparison is not between values of the same thing, as in the previous chart, but between two closely related things, namely, *land value*, and *crop value*. That the crops for one year actually cover a satisfying proportion of the land value is the principal idea which the chart is intended to convey.

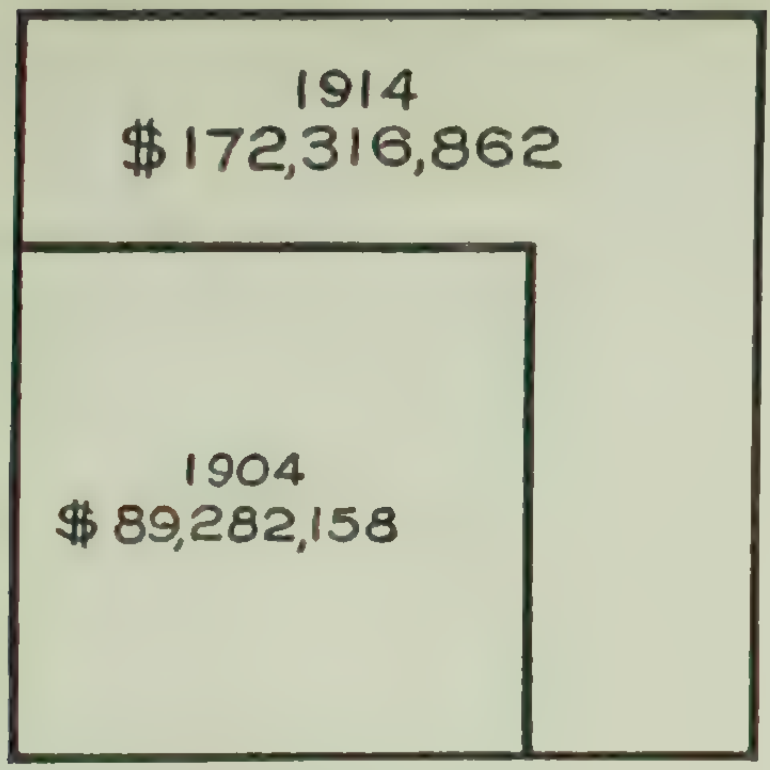


Fig. 17. Comparison of Same Data as in Figure 16, by Means of Superimposing the Smaller Area upon the Large One

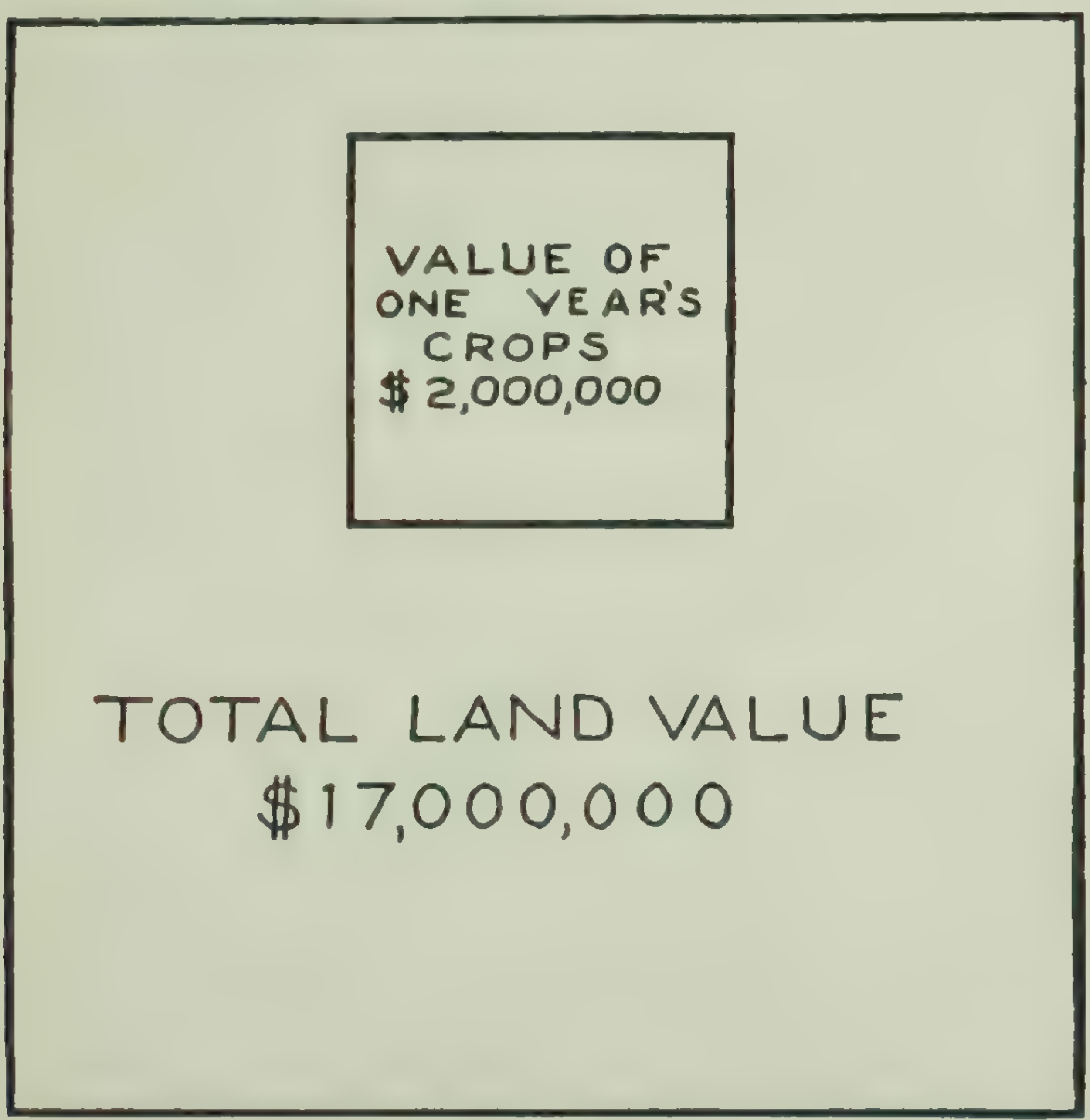


Fig. 18. Crop Values of San Mateo County, California, in Relation to the Value of the Land

(From *Reorganization of a County System of Rural Schools*. United States Bureau of Education Bulletin no. 16. 1916.)

Triangles and other shapes. The values represented in Figures 16 and 17 are shown in triangular form in Figure 19. Here again the comparison is in area. The most prominent feature of a triangle, however, is its height, or altitude. Even if the reader understands that it is the areas that are to be compared, such comparison is more difficult to make with triangles than with squares or rectangles. The same is true of trapezoid shapes, which should also be avoided. These unusual shapes are often more striking in appearance than squares and rectangles, which accounts for their frequent use. They do not lend themselves, though, to accurate perception.

In Figure 19 the use of the border is illustrated. This is a desirable feature, and will be found in nearly all of the subsequent charts in this book. The border usually designates the extreme outer limits of the chart, and should include within it every part that is to be reproduced. Its extent is determined by the shape and content of the drawing, and in accordance with the general rules of proportion. Margins too wide or too narrow detract from the appearance of otherwise well-drawn charts. Unnecessarily wide margins add to the cost of photo-engravings, which are based on the total area included within the border.

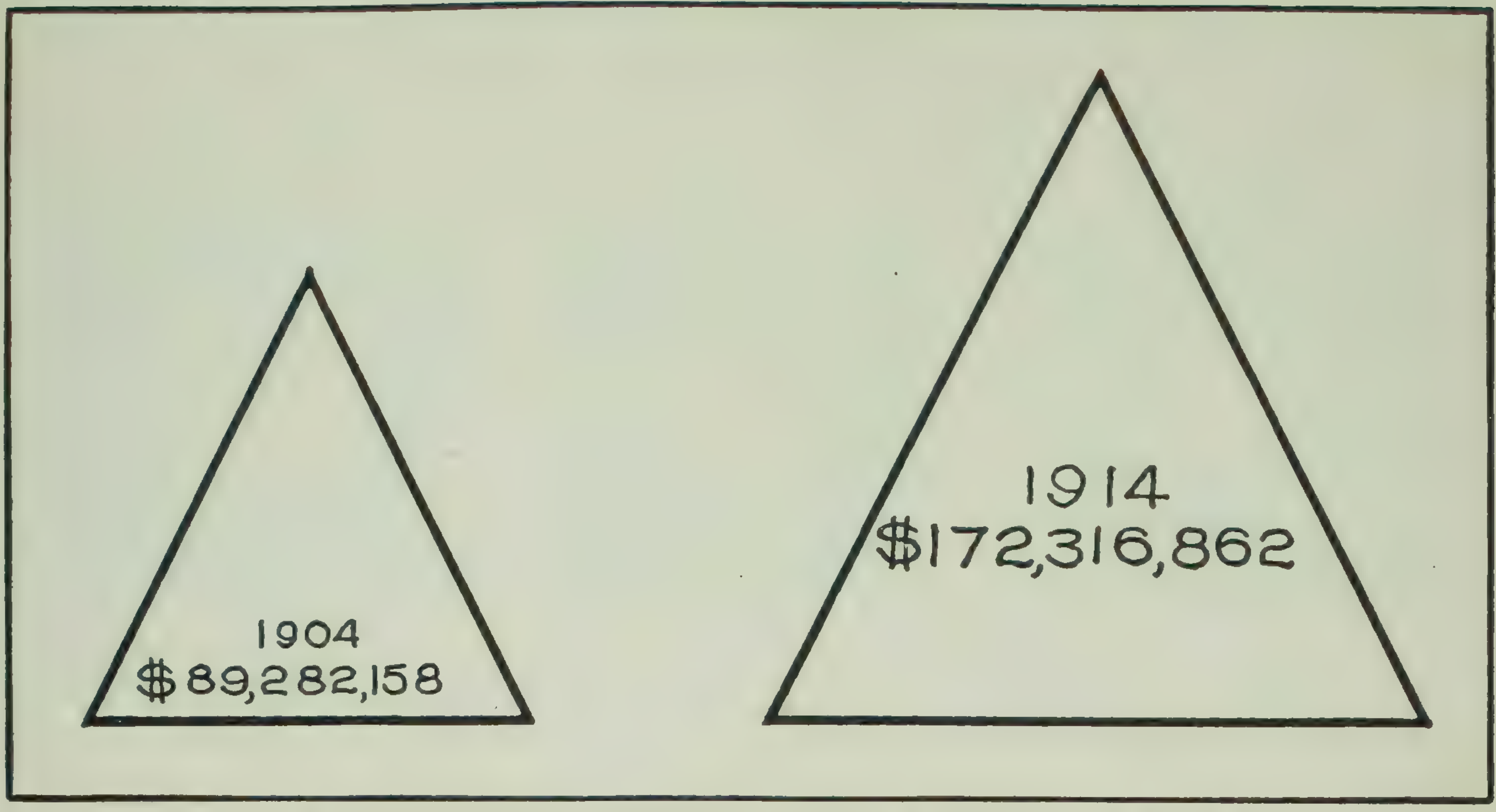


Fig. 19. Another Method of Comparing the Crop Values Shown in Figure 16

Proportionate exposures. Figure 20 represents schoolroom lighting conditions in Springfield, Illinois, in comparison with the accepted standard. The basis of measurement is the ratio of window area to floor space. The outer limits of each of the three squares represents a unit of floor space, while the white portions indicate the standard amount, Springfield's average, and Springfield's smallest, respectively. The psychological effect of using the white squares within black areas is obvious. These are really superimposed squares, and are subject to the errors of perception previously indicated. The method is effective, however, and gives a much better idea of the lighting situation than could be obtained through verbal description or tabular data.

The "inking-in" process, as described in the instructions for Practice Sheet Number 4, has been used in the construction of this chart.

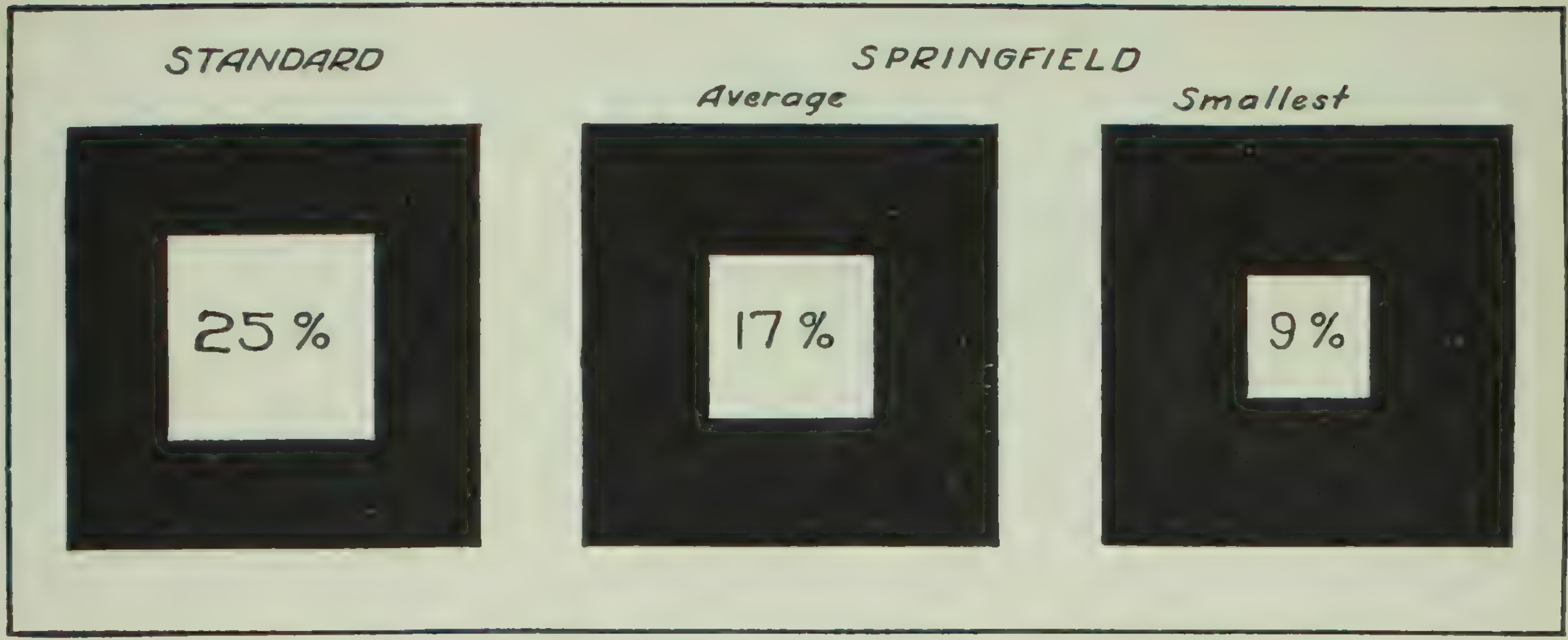


FIG. 20. SCHOOLROOM LIGHTING IN SPRINGFIELD, ILLINOIS, IN COMPARISON WITH THE STANDARD
(From *The Springfield Survey.*)

Shaded-area comparisons. The use of shading, by means of single and double hatching, is illustrated in Figure 21. Here three simple areas, in rectangular form, represent the percentage of pupils who entered high school from the low third, middle third, and high third, of their elementary-school classes. The basis of comparison is the height of the rectangles, and the method is valid in this case because the columns are of uniform base measure.

The middle rectangle is double hatched, so that it will stand out in contrast to the others. Note that the slope of the single hatching on both sides is upward toward the center. These lines are extended into the middle area, and their intersection produces the double hatching. The slope in this instance is 45°, and the lines are drawn with the aid of T-square and triangle, as explained in the instructions for Practice Sheet Number 3.

Another feature introduced in Figure 21 is the use of the vertical scale at the left of the chart. The *base line*, which is drawn heavy, represents zero. At the top is an equally heavy line representing 100 per cent. The space between these two lines represents the percentage of cases for each group represented by the vertical columns. The shaded area for each column, drawn according to the scale, is the part under consideration. A series of horizontal *guide lines* is shown, their values being indicated on the vertical scale. Any number of guide lines may be used, but in this instance the interval chosen is deemed sufficient. The purpose of the lines is to guide the eye in judging the height of the columns.

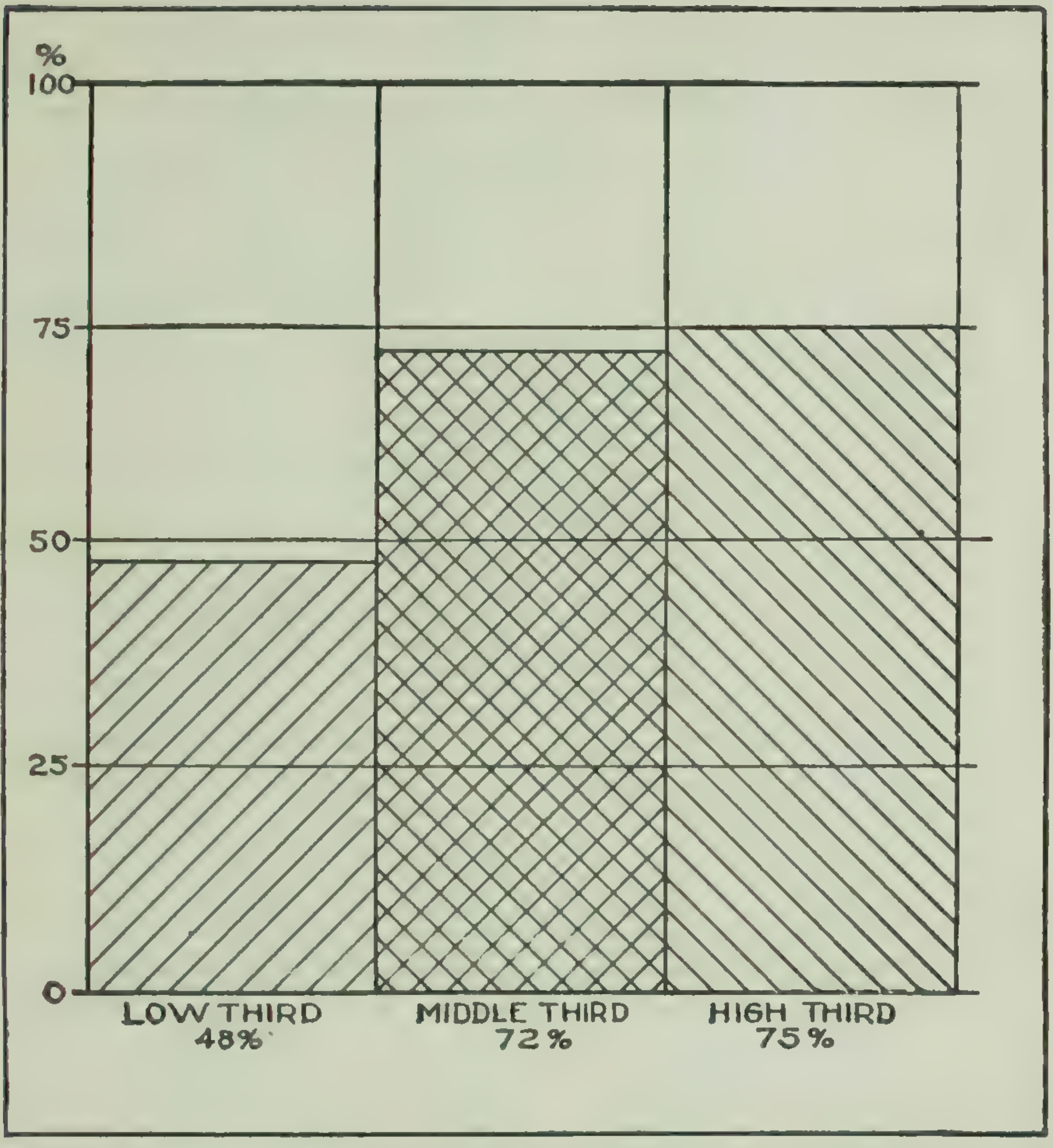


FIG. 21. PERCENTAGE OF PUPILS IN CLEVELAND ENTERING HIGH SCHOOL FROM THE LOW THIRD, MIDDLE THIRD, AND HIGH THIRD OF THEIR ELEMENTARY-SCHOOL CLASSES

(Data from *The Cleveland Survey*.)

Component parts. In Figure 22 we have a rectangle extending horizontally, the length of which represents all, or 100 per cent, of the cases under discussion. The area is divided into five parts, each of which represents a sub-group. The size of each part is proportional to its percentage value. The name and value of each is plainly indicated.

In this case the scale is horizontal, and the heavy lines representing zero and 100 per cent occur at the left and right, respectively. A series of guide lines divides the large rectangle into tenths. The guide lines are not drawn through, but jump across, so that only their ends are seen. Drawing them through would cut the rectangle into so many segments that the areas under comparison would not show plainly.

Another form of this chart, in which the parts are represented as shaded areas, will be seen in a subsequent figure.

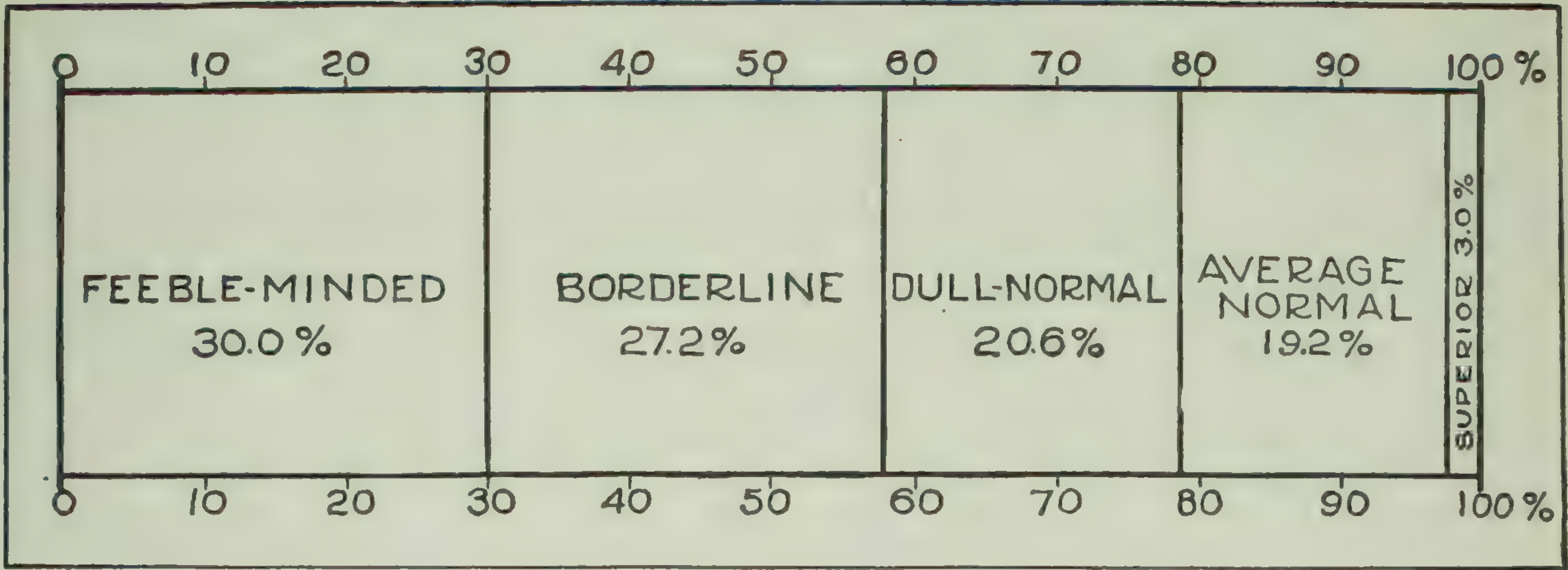


FIG. 22. SOCIAL-INTELLIGENCE CLASSIFICATION OF A GROUP OF BOYS IN A STATE INDUSTRIAL SCHOOL
(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

Comparative component parts. The comparison of two component part rectangles is shown in Figure 23. By this method the school expenditures of a city are compared, by separate items, as component parts of the total expenditure, 100 per cent. The rectangle for Elyria, which is the city for which the comparison is being made, is shown at the top, the comparative data being placed directly below it. Lines are drawn connecting the limits of the respective component parts, to guide the eye from one to the other. The guide lines show at their extremities only, for reasons previously explained. Heavy zero and 100 per cent lines appear at the left and right, one of each serving for both rectangles. The numerical scale is shown at the bottom, in accordance with the standard procedure.

This chart is not surrounded by a border, because of the confusion which so many lines might cause. It happens that its limits virtually constitute a border, although parts extend slightly beyond.

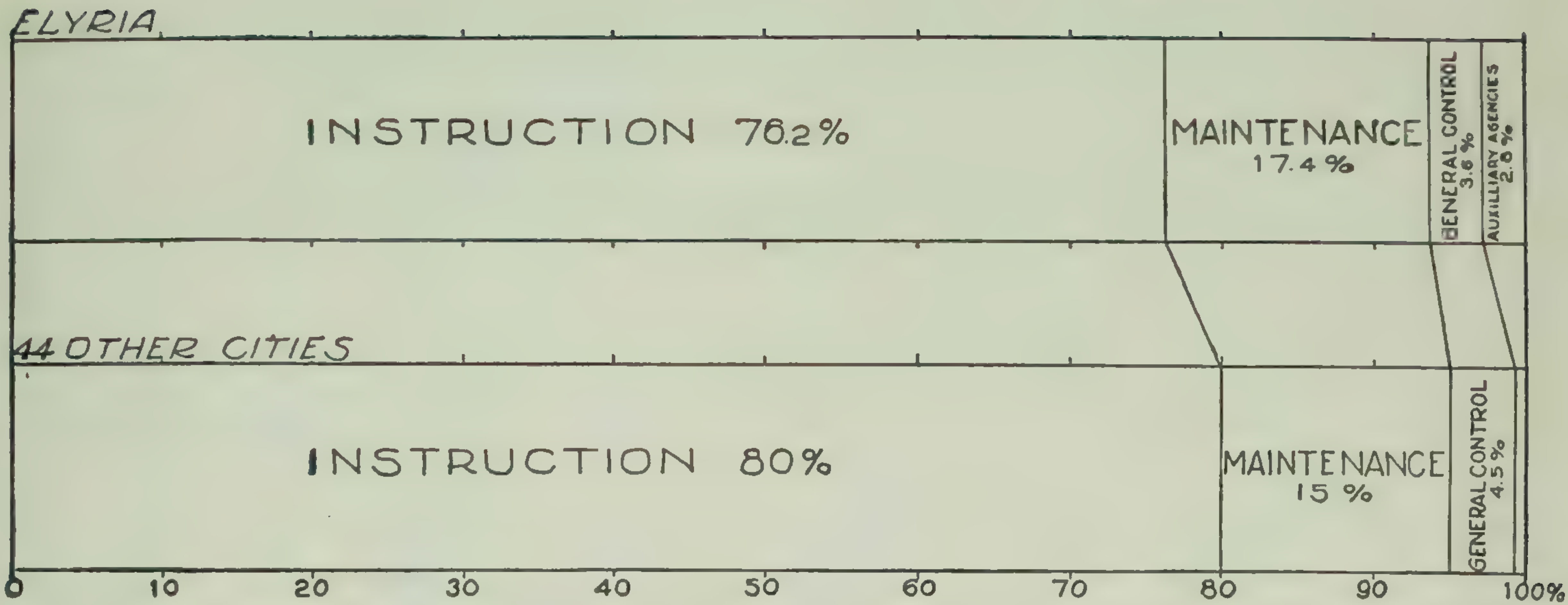


FIG. 23. COMPARISON OF ELYRIA, OHIO, WITH FORTY-FOUR OTHER CITIES IN DISTRIBUTION OF EDUCATIONAL EXPENDITURES
(From United States Bureau of Education Bulletin no. 15. 1918.)

Shaded component parts. The rectangle in Figure 24 is divided into three parts, of such values that a percentage scale is not necessary. Moreover, it represents only approximately ascertained facts, and their exactness is not under consideration. The striking feature of the chart is the preponderance of one of the groups over the other two. The large group is indicated at the bottom, and is the most heavily shaded; while the top section is shown without shading. If these were reversed the column would give an unpleasing appearance of top-heaviness, as can easily be seen by inverting the page.

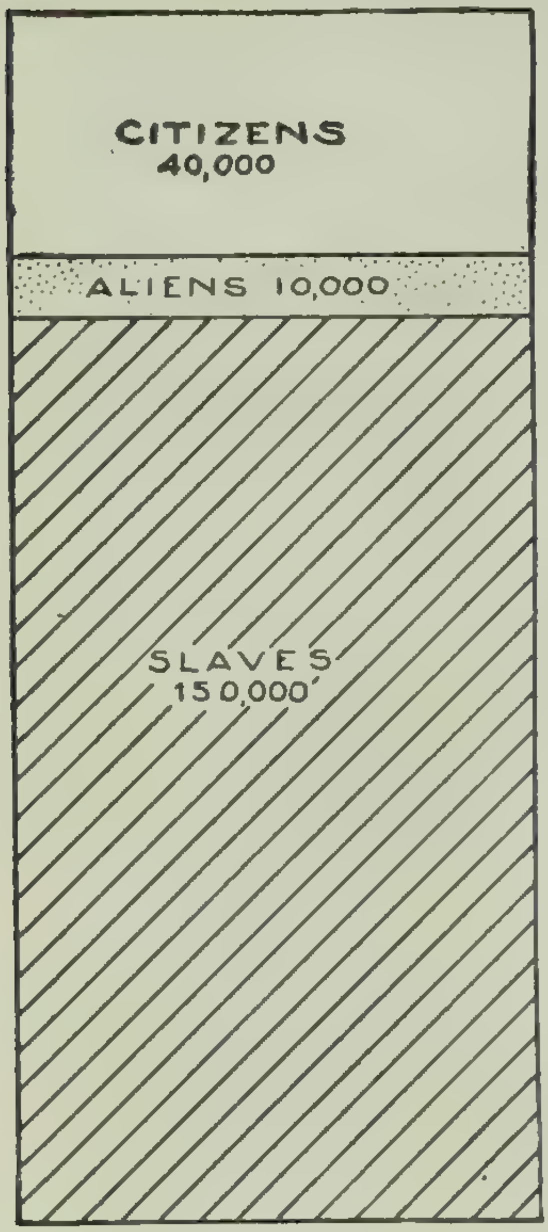


FIG. 24. DISTRIBUTION OF THE POPULATION OF ATHENS AND ATTICA, ABOUT 430 B.C.
(From *The History of Education*, by E. P. Cubberley.)

In Figure 25 shaded component parts are seen in comparative rectangles. The data for the upper bar are the same as used in Figure 22. Except for the shading, this chart is of the same type as Figure 23. Shading is graduated from left to right, beginning with the heaviest. In this case the solid black is appropriate for feeble-mindedness, which is an undesirable, pathological condition. One of the important results of the investigation on which this chart is based is the relative proportion of mental deficiency among delinquent children, and this fact is forcibly brought out by the shading.

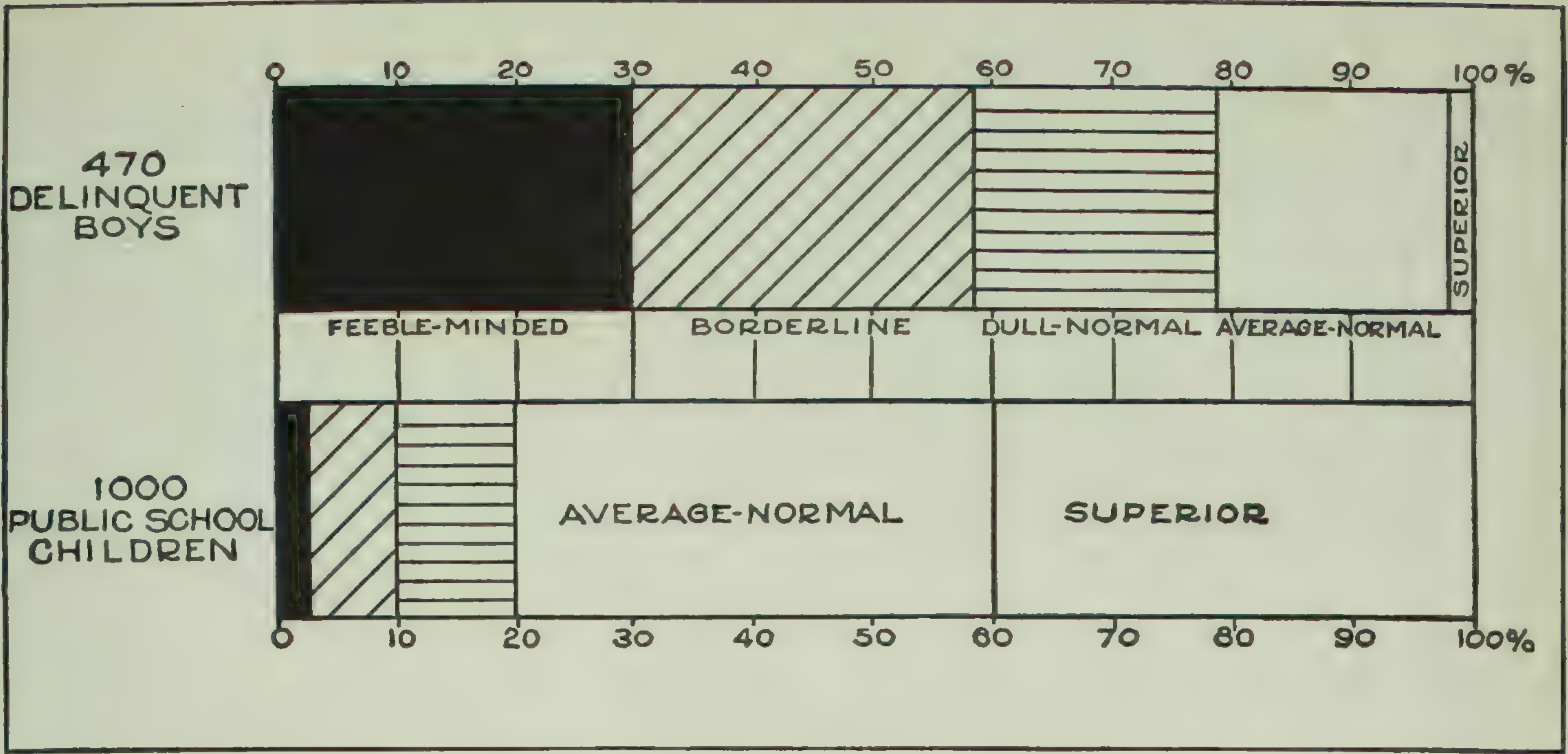


Fig. 25. Social-Intelligence Classification of the Group of Boys Shown in Figure 22, in Comparison with Unselected School Children of the Same Ages

(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

Use of the double scale. Figure 26 is a component-part rectangle, representing 408 cases of absence from school. The attendance officer reported seven causes for the absences, and here they are grouped, according to their frequencies, with the largest group at the bottom. The more important groups are represented by shaded areas, graduated in lightness from bottom to top. The causes, together with the number of cases of each, are indicated at the right. The zero and 100 per cent lines are shown according to the standard method.

On the left of the chart a vertical scale is constructed to show the *actual number* of cases. The chart is 408 units in height, and the guide lines are shown at intervals, represented by round numbers. At the right of the chart another vertical scale shows the *percentage* of cases, with guide lines at intervals of 10 per cent. With the aid of the two scales, a correct idea may be formed of the relationship of sub-groups to each other, and to the entire group under consideration.

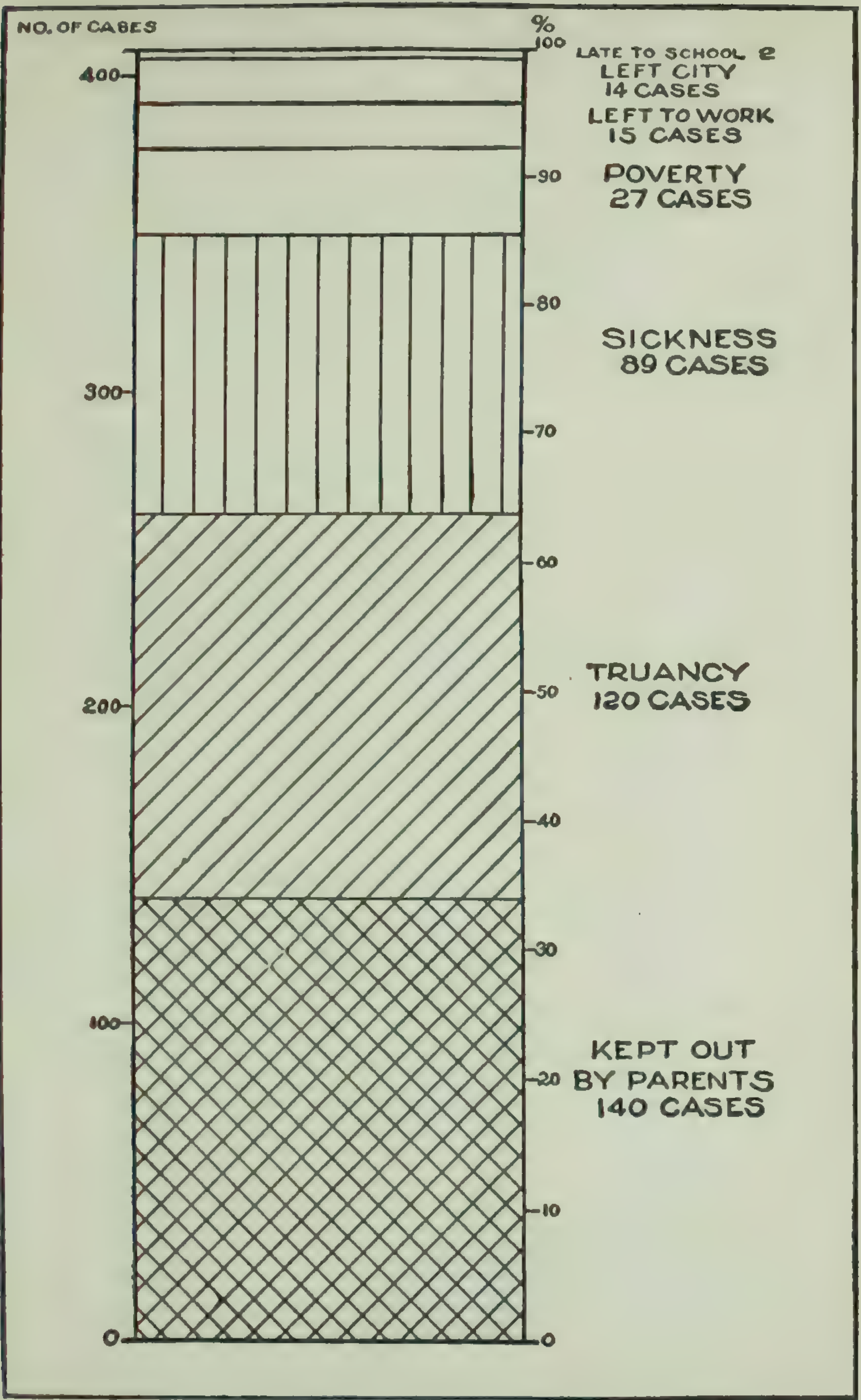


FIG. 26. ATTRIBUTED CAUSES IN 408 ABSENCE REPORTS BY SCHOOL ATTENDANCE OFFICER IN ELYRIA, OHIO

(From United States Bureau of Education Bulletin no 15. 1918.)

PROBLEMS FOR CHARTING

1. Reconstruct Figure 16 in the form of rectangles having equal bases.
2. Reconstruct Figure 20 in the form of rectangles of equal bases, in which the upper end of each will show the proportion of lighting area.
3. Reconstruct Figure 21, separating the columns slightly, so that they will stand out more conspicuously.
4. Reconstruct Figure 22 in the form of five rectangles of equal bases.
5. Construct a chart similar to Figure 24, based on the latest United States census data regarding the principal racial groups. At the left of the column show a vertical percentage scale, as in Figure 26.
6. Recently the institution referred to in Figure 25 has reduced its proportion of feeble-mindedness by transferring a large number to another institution. The new percentage distribution is reported as follows:

Superior	3.0
Average-normal	35.4
Dull-normal	36.7
Borderline	20.7
Feeble-minded	4.2

   Construct a chart in which the new data will appear in a third segmented area in addition to those shown in Figure 25.

7. Following the plan of Figure 26, construct a double-scale chart from the following data:

CAUSES OF TRUANCY IN 105 CHILDREN

Individual	25 cases
Environmental	20
Associational	22
Individual and environmental	10
Individual and associational	3
Environmental and associational	0
Individual, environmental and associational	16

CHAPTER IV

BAR REPRESENTATIONS

(Explaining Figures 27 to 48, Inclusive)

General definition. Bar charts are characterized by the exclusive use of parallel rectangles, or columns, several of which, uniform in base measure, are shown in each chart. The values are comparative, as in the case of simple area charts, but more facts are given in a bar chart. A row of bars or series of columns may represent a group of disconnected, but related, facts; or a series of closely connected facts, such as intervals of time, school grades, etc. The value is always represented by the length of the bar. Bar charts occur in two forms, horizontal and vertical.

Horizontal bar charts are constructed so that the rectangles extend from a vertical base line, at the *left* side, which represents zero, and the value of each item is indicated by the length of the bar, measured from that line. The measure is indicated by a horizontal scale along the bottom of the chart.

Vertical bar charts are constructed so that the bars stand upright, like columns, on a horizontal base line representing zero, and from which the measurements are indicated on a vertical scale at the *left* side.

Horizontal bars are generally preferable to vertical bars, because of the greater accuracy with which the eye can compare horizontal distances. Vertical distances are often misleading, for we do not uniformly judge the upper and lower portions. There are many instances, however, in which ideas can be conveyed better by vertical columns. In this chapter both types of charts are shown.

1. Horizontal bar charts

Simple horizontal bars. The use of the horizontal bar chart in its simplest form is seen in Figure 27. The purpose of the chart is to indicate the extent to which collegiate geography played a part in the training of a group of teachers. Time intervals of none, 12 weeks, 18 weeks, 24 weeks, 36 weeks, and over 36 weeks, are chosen, and these are shown at the left. Then follows a vertical base line, representing zero on the percentage scale. The length of each bar, measured from left to right, indicates the percentage of teachers who received a certain number of weeks' training in geography. For example, the top bar shows that 5.5 per cent had studied the subject more than 36 weeks; the next lowest bar shows that 7 per cent studied it 36 weeks. The bottom bar shows that 16 per cent did not take the subject at all. The combined length of the bars, if placed end to end, would equal 100 per cent on the scale.

Note that a series of guide lines is constructed from the scale at the bottom. These aid in the visual comparison of the bars, and from them the length of each bar can be determined quickly with a reasonable degree of accuracy. The numbers in the scale are not repeated at the top, because the height of the chart does not require it.

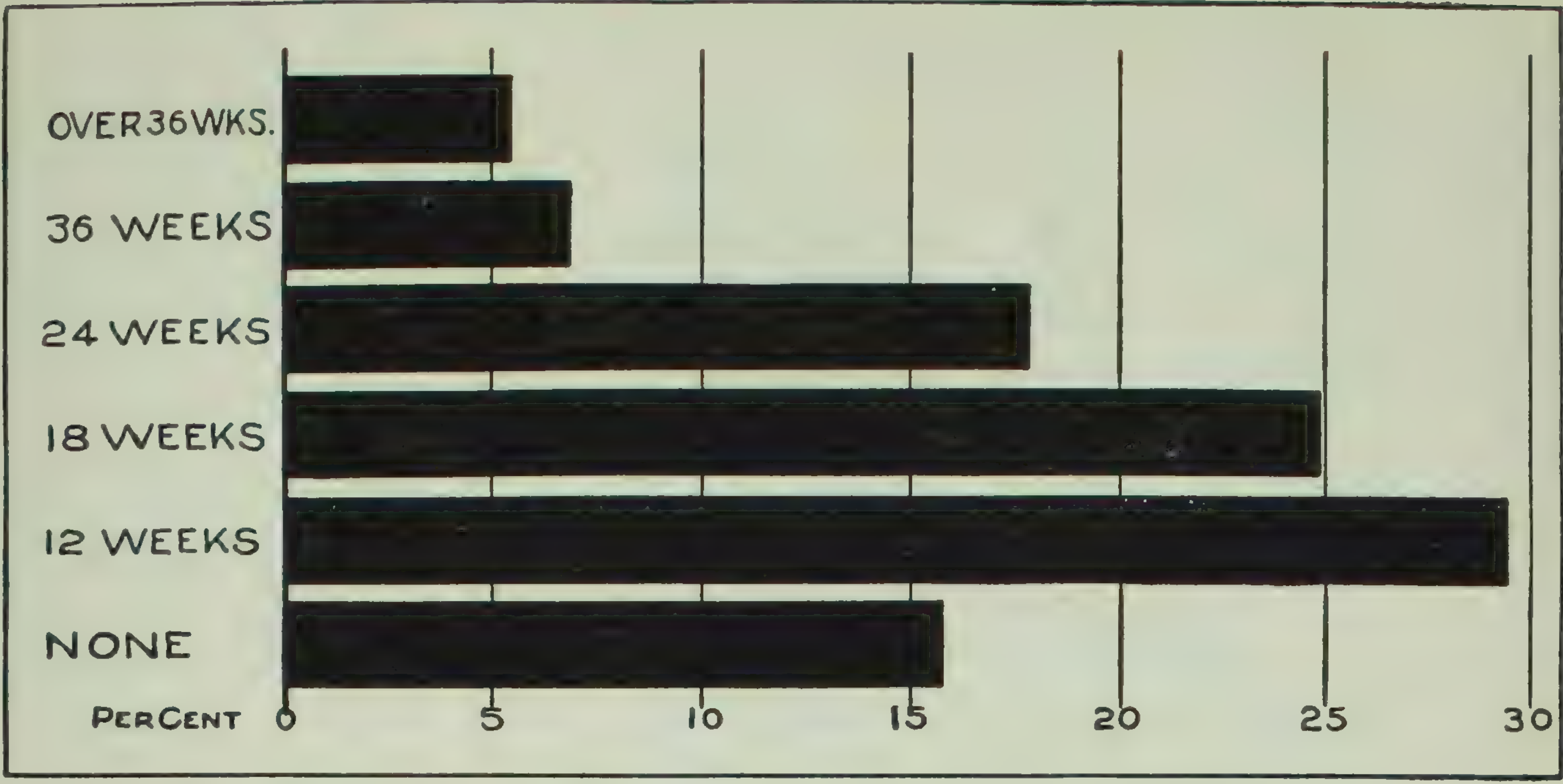


FIG. 27. COLLEGIATE GEOGRAPHY IN THE TRAINING OF 5406 RECENT NORMAL-SCHOOL GRADUATES
(From *Journal of Geography*, January, 1922.)

Horizontal bars to show other data. In Figure 28 the bars represent a group of school buildings in Boise, Idaho. The purpose is to show their respective ages. Inasmuch as the age of a school building decreases its desirability and efficiency, they are arranged in order, with the oldest at the bottom. The Roosevelt School, which was under construction at the time this chart was made, is shown in its correct position, but without a corresponding bar. Note the guide lines, distributed by intervals of five years, and observe how easily the age of each building can be told by their use. The scale is repeated at the top, which procedure is advisable for a chart of this size.

The names of the schools are lettered at the *left*, with their initial letters in line. Each word is spaced according to the middle of the base of its corresponding bar. The height of the letters is about one-half the bar thickness.

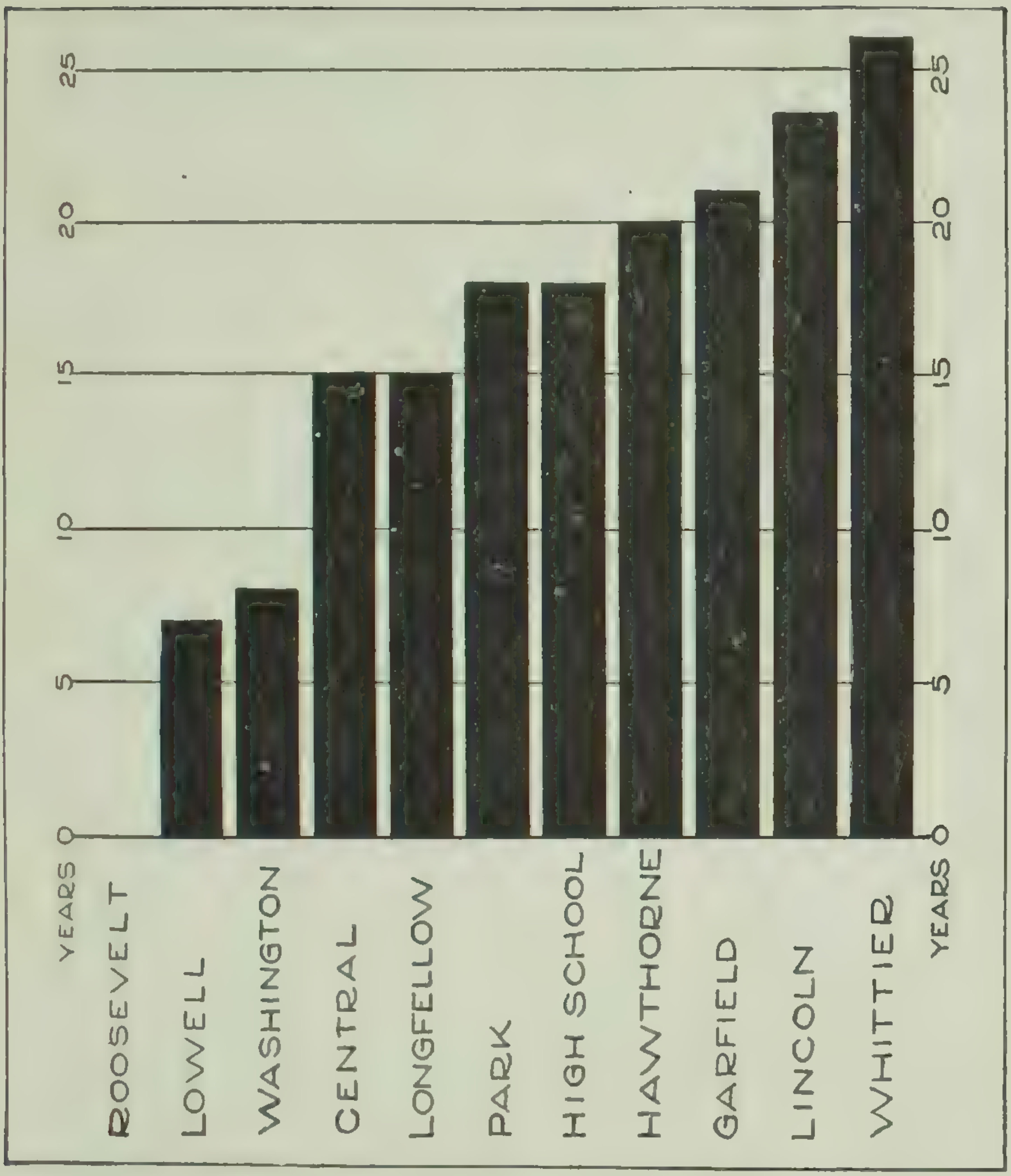


FIG. 28. AGES OF SCHOOL BUILDINGS IN BOISE, IDAHO, IN 1919
(From *The Boise Survey*, by J. B. Sears.)

Component-part bars, without scale. Figure 29 shows a group of five horizontal bars, each of which represents the population of the United States according to the census. Inasmuch as the comparison is to be on a percentage basis, the bars are of equal length, each representing the entire population, or 100 per cent. The component parts of each bar are the urban and rural population; the former being shown in single hatching, and the latter as white space. There is no scale indicated here, as there are but two component parts, and the exact data are given for each group.

The time intervals are arranged to read from bottom to top, in accordance with standard procedure. This order gives us the latest facts, namely, those for 1920, at the top, where their practical importance would logically place them.

This chart shows how easily bar charts may be made to represent growth, or trends, by time intervals. The bars are close enough together to cause the shaded portion, at the left, to give the appearance of a single area, widening toward the top. This is exactly the impression it is desired to give; there has been a gradual expansion of the urban population of the United States. Note also that this widening shaded area encroaches on the white area, at the right, so we get an impression of shrinkage as the eye moves toward the top.

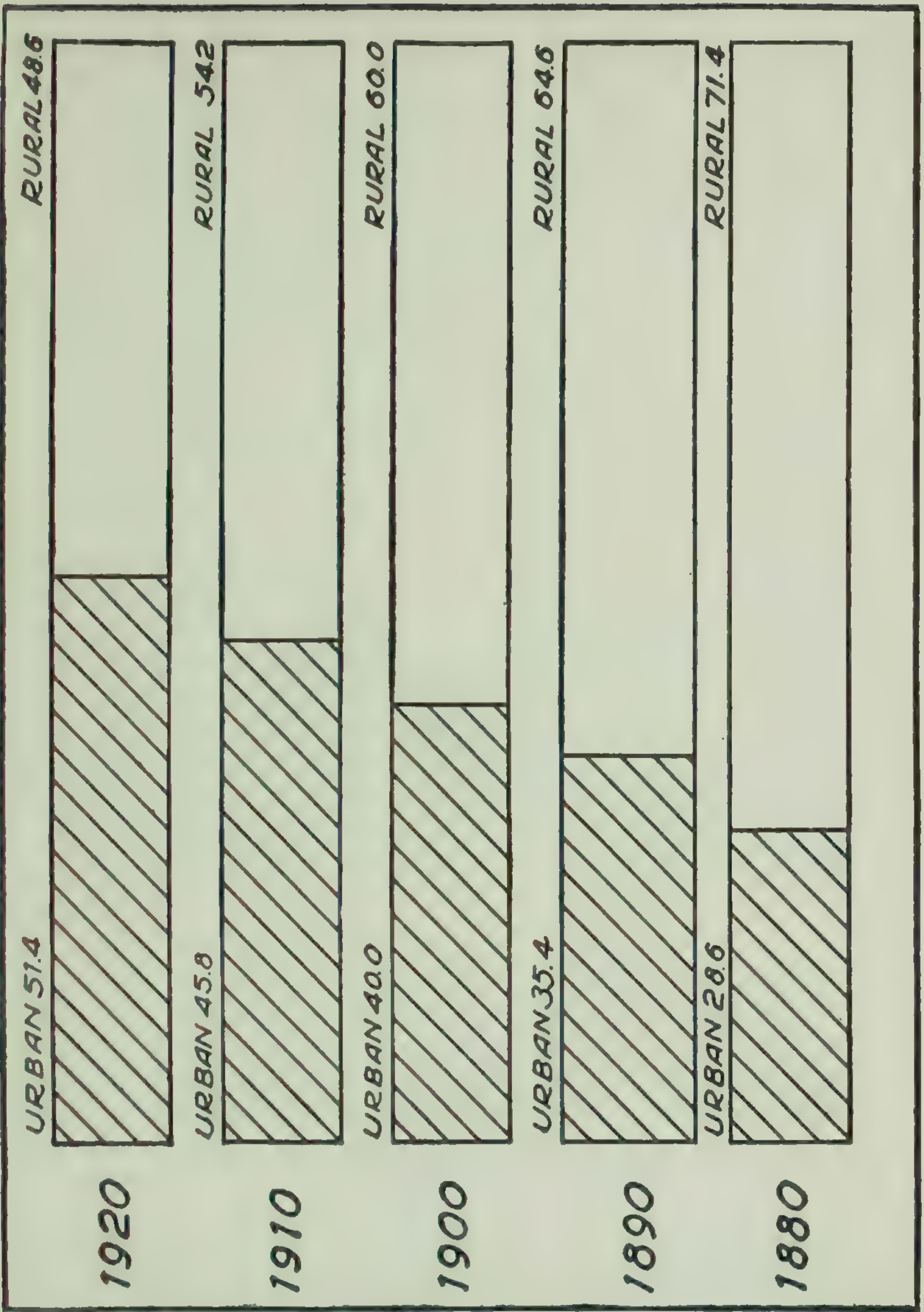


FIG. 29. CHANGE IN PERCENTAGE OF URBAN AND RURAL POPULATION 1880–1920

(Data from United States Census, 1920.)

Component-part bars, with scale. Figure 30 is similar to the preceding chart, except that, in this instance, we are really concerned with but one part of each 100 per cent bar. The comparison is based on the proportion of feeble-minded boys among several groups of delinquents, classified according to the principal reasons for which they were committed to a state institution. The number of cases for each offense varies, as in the census chart, but they are equalized for the purposes of special comparison. The items are arranged, not in the order of actual frequency, but according to the percentage frequency with which mental deficiency occurred. Unless this point is kept in mind the chart may be misleading. For example, there were but two cases of murder; and inasmuch as both of these boys were feeble-minded, the 100 per cent bar is completely inked-in. So small a frequency is subject to a large error; hence it must not be assumed from this chart that all juvenile murderers are feeble-minded. On the other hand, most of the offenses represented in the chart occur with such frequency that the chance of error is much less. It is also probable that the mental-deficiency order as shown here approximately indicates the relationship between the several forms of misconduct and the intelligence of delinquent children.

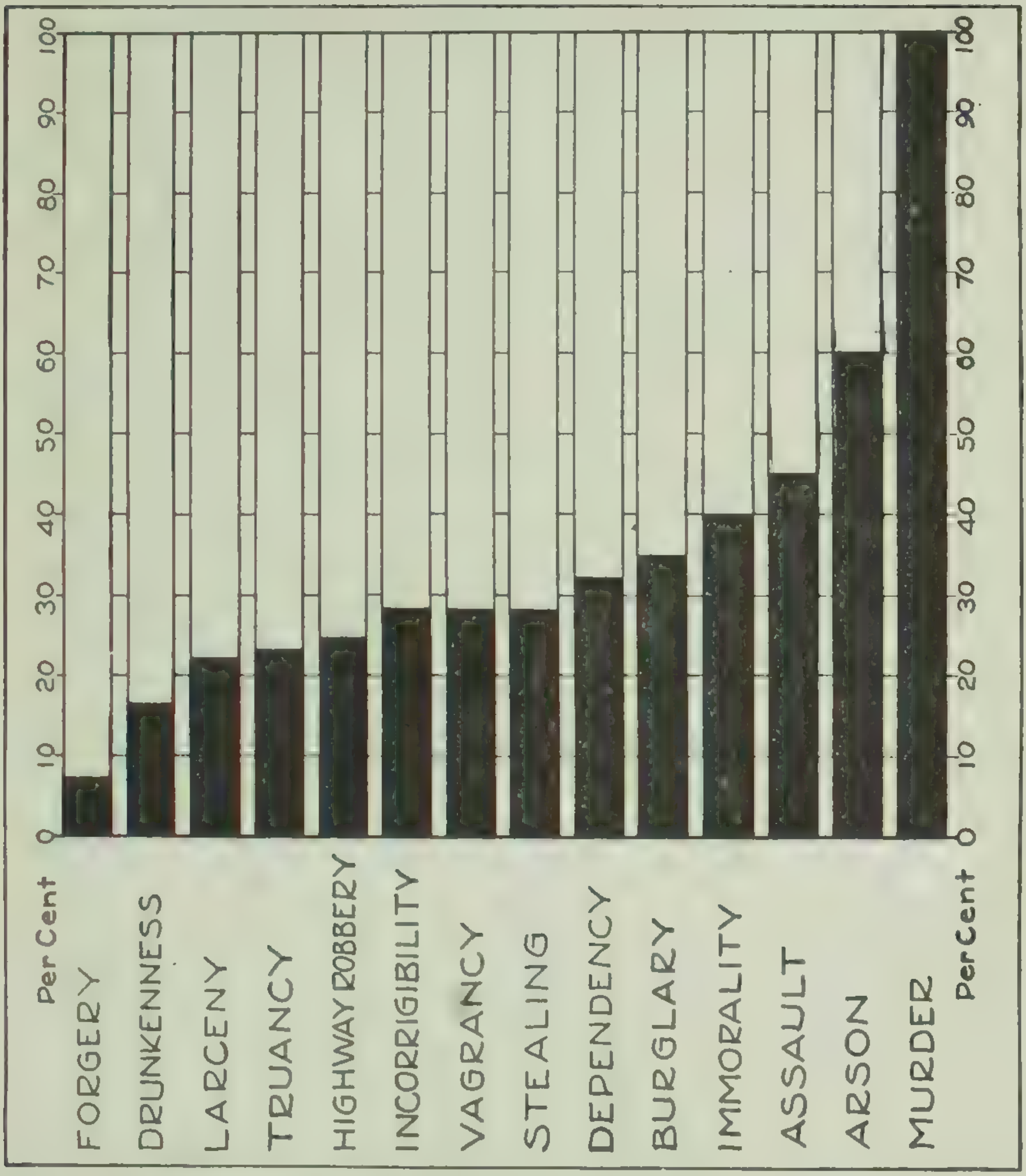


FIG. 30. DISTRIBUTION OF THE PRINCIPAL OFFENSES OF DELINQUENT BOYS ACCORDING TO THE PERCENTAGE OF FEEBLE-MINDED IN EACH GROUP

(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

Component-part bars, showing total percentages. Another form of component-part horizontal bar chart is illustrated in Figure 31. Here is shown the intelligence of seventeen national and racial groups, according to the results of the Army mental tests made during the period of the late mobilization. Each bar represents all of the cases, or 100 per cent, of the group designated by the lettering underneath it. The number of component parts is three, representing inferior, average, and superior intelligence, respectively. The arrangement is according to the test ranking, the highest being at the top, the lowest at the bottom. Bars 6, 9, and 16 show the combined data for general groups — native-born white draft, total white draft, and foreign-born white draft. At the bottom of the chart is the percentage scale, divided into intervals of 10 per cent. The guide lines are not extended through the entire chart, as is sometimes done, because of the thinness of the bars and their spacing. The extension of the lines would cut the spaces into segments which would be confusing.

Below the scale appears the *key*, or *legend*, consisting of three short bars representing, respectively, each of the three groups into which the bars are divided. Without the key the chart would be incomplete, unless each of the nationality bars were separately marked according to the meaning of the solid, single-hatched, and white areas.

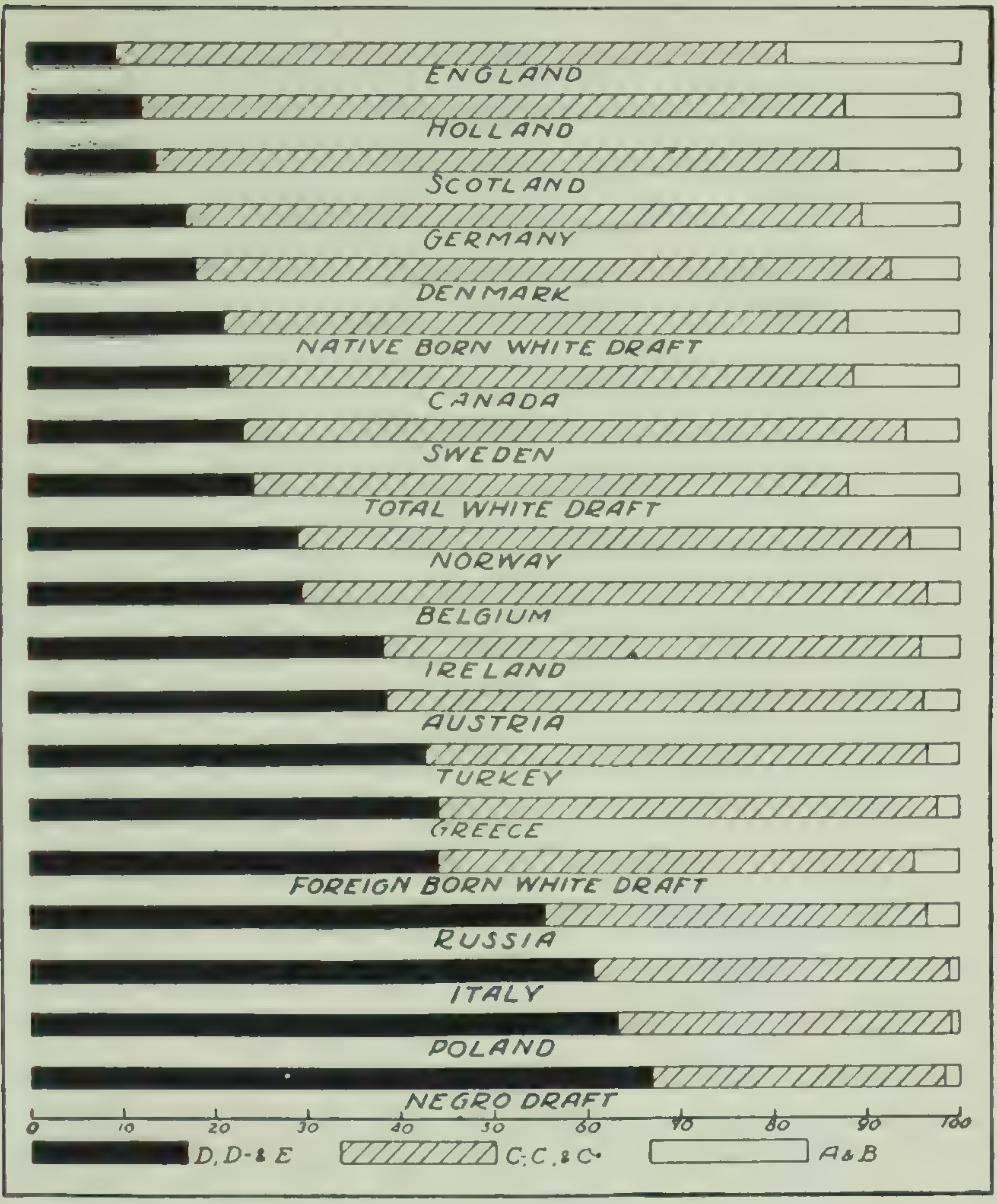


FIG. 31. RESULTS OF ARMY INTELLIGENCE TESTS IN VARIOUS NATIVITY GROUPS

(From *A Study of American Intelligence*, by C. C. Brigham. Princeton University Press, 1923.)

Component-part bars to represent unequal values. Figure 32 illustrates the use of component-part bars for representing a series of unequal values. In this instance, two things are shown: (1) the frequency of occurrence for each offense (stealing, burglary, etc.), and (2) the intelligence classification of each group. The frequencies relate to the actual number of cases; not to percentages, as in the three previous charts. Each bar is divided into five component parts, representing five intelligence groups, as indicated in the key. The scale, numbered at the bottom, ranges from zero to 120, and is divided into guide-line intervals of twenty cases each. These are chosen with regard to readability and neatness of spacing. The length of the chart is determined by the next round number above the measure of the longest bar. Inasmuch as the showing of frequency is the main purpose of the chart, the bars are arranged in that order, with the highest frequency at the top.

A glance at this figure gives the reader, without much previous information on the subject, a clear and accurate idea of several important and related facts in juvenile delinquency. When first shown in connection with the report of a survey of such a group, it was said by many persons to be more "telling" to them than the whole of the verbal report.

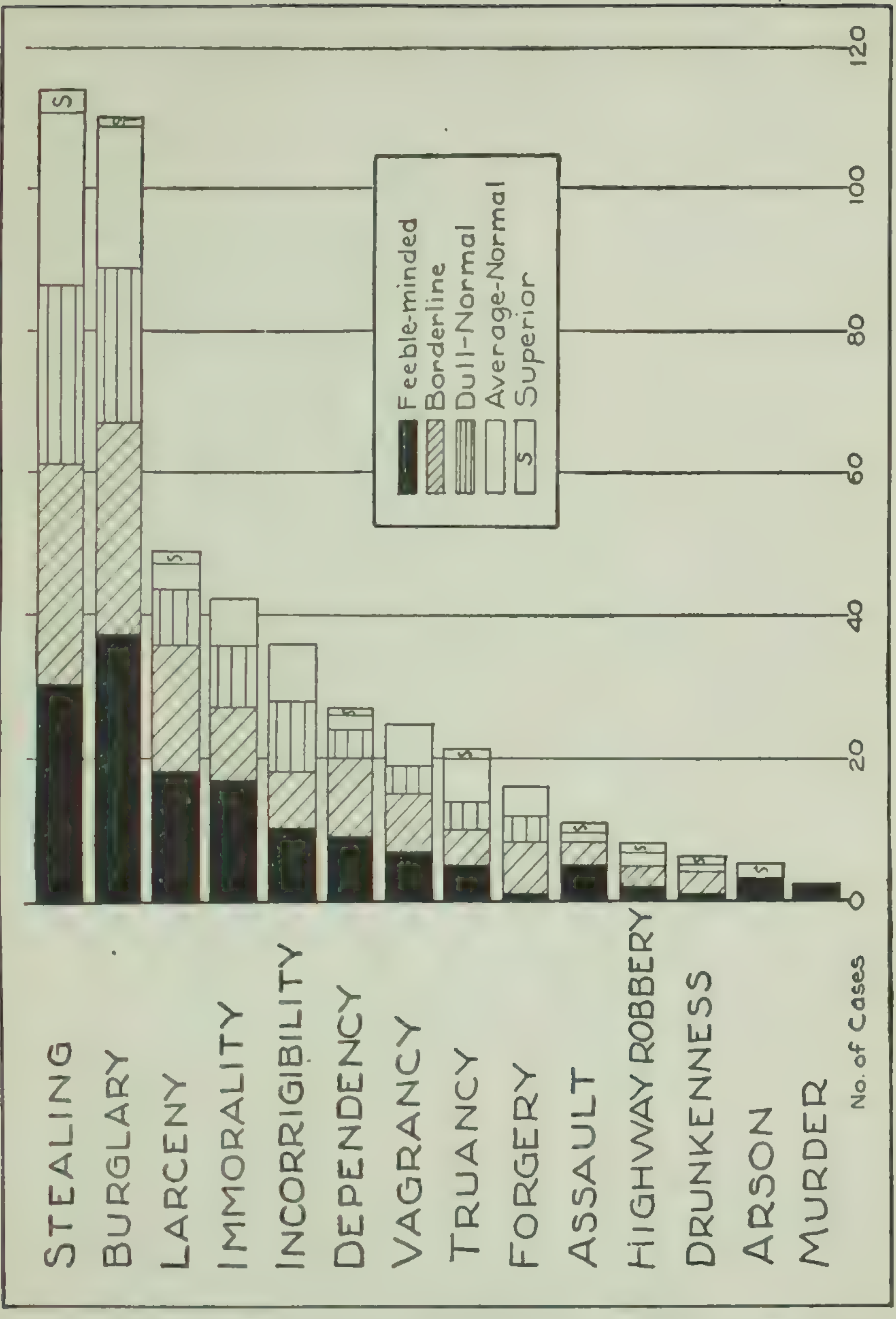


FIG. 32. FREQUENCY DISTRIBUTION OF A GROUP OF DELINQUENT BOYS ACCORDING TO INTELLIGENCE AND PRINCIPAL REASONS FOR COMMITMENT

(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

Comparisons with standard score. How the school buildings of a city rate according to a standard grading scale is shown in Figure 33. The scale includes 1000 points, which would be the rating of a building conforming to the highest standards of construction and efficiency. A bar running the full length of the chart, representing a 1000-point building, is placed at the top, because it represents the highest attainable score. This bar is single-hatched.

Below it are drawn ten bars, also full length, but inked-in, from left to right, according to the score of the building it represents. The inking-in differentiates the school bars from the standard, and their heavier appearance shows that they are the important items under consideration. The best building is shown at the top, just below the standard bar, and the poorest is at the bottom. The scale zero to 1000 points is shown at both bottom and top. Guide lines are shown in intervals of 100 points. The zero and 1000-point lines are heavy, because they represent the limits of the measure, as in a percentage scale.

The increasing use of standard measurements in educational work makes it especially desirable to use such comparisons as this. Test ratings of a group of schools may be compared with the established average for the city; results of educational achievement tests may be shown in relation to the achievement quotient standard; school costs may be seen in comparison with an average of standard determined by the measurement of costs in all the cities of a given area. Comparisons with standards are much more satisfactory and enlightening than the traditional type of comparison.

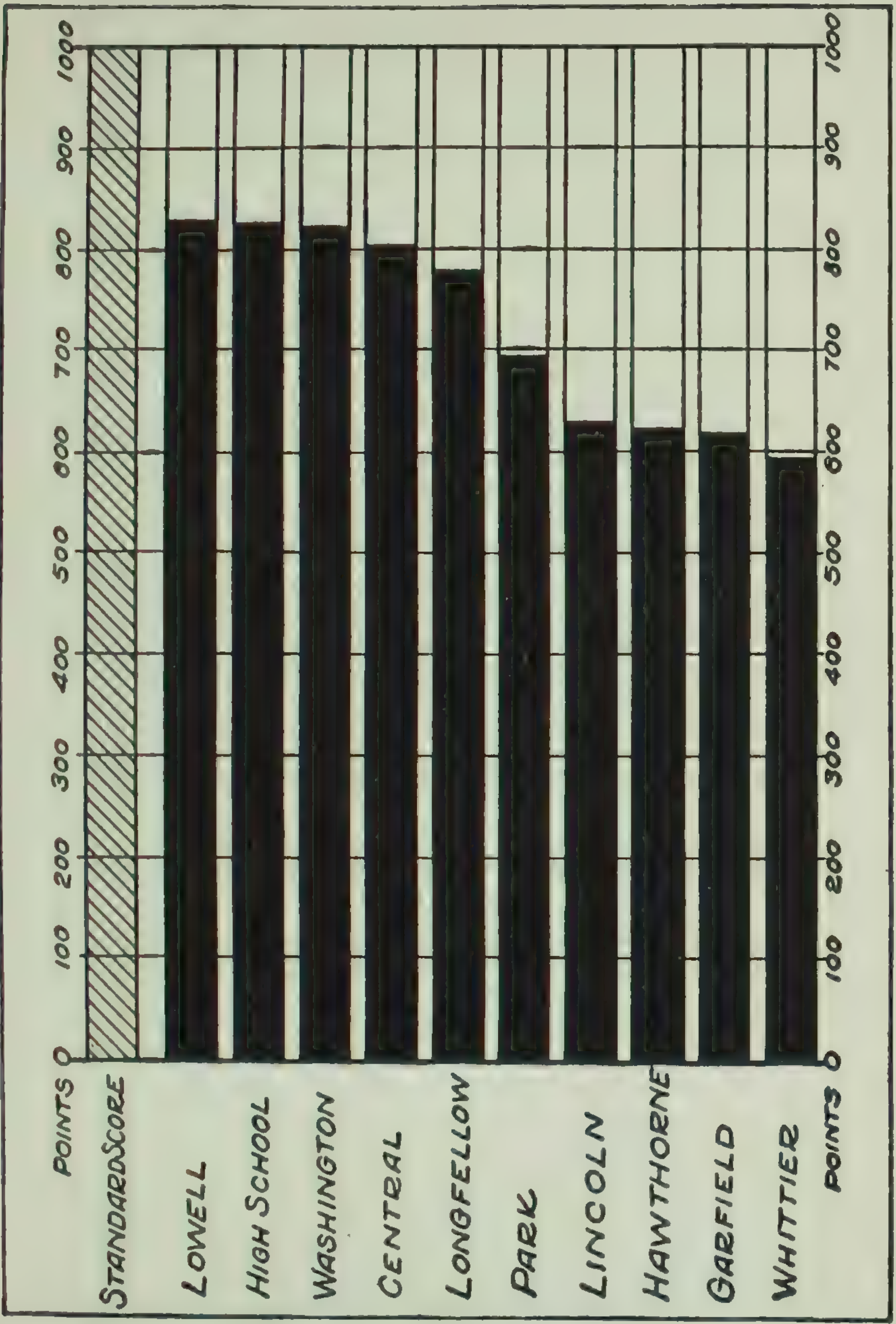


FIG. 33. RATINGS OF SCHOOL BUILDINGS IN BOISE, IDAHO, ACCORDING TO THE STRAYER SCALE

(From *The Boise Survey*, by J. B. Sears.)

Extension bars. Figure 34 shows how horizontal bars may be used for comparison, even when their proportions are greatly different. This chart represents the railroad mileage of the leading countries of the world, a single line, by its length, indicating the mileage for one country. The United States, which is far in the lead, is shown first. The total length of the line cannot easily be measured with the eye, and the method would not be satisfactory were it not for its predominant character when folded in several layers running the width of the chart. In view of the thing represented, railroad mileage, a psychological effect is produced by the use of thin extended bars running in more than one direction. The lines representing the other countries, measured on the same scale, are more easily compared with each other, as in standard horizontal bar charts. If a standard frequency chart had been attempted, as in Figure 32, with the United States represented by a bar running the width of the chart, the bars representing the smaller countries would be of imperceptible size. The scale is not shown, and no guide lines are possible, because the full distance represented by some of the bars is greater than the width of the chart. The exact mileage for each country is shown numerically, which here is more satisfactory than percentages would have been.

Notwithstanding the limitations of this chart, it is probably the best way of showing the comparative railroad mileage of the world and similar data in a small space, and most persons would agree that it is better than a statistical table alone.

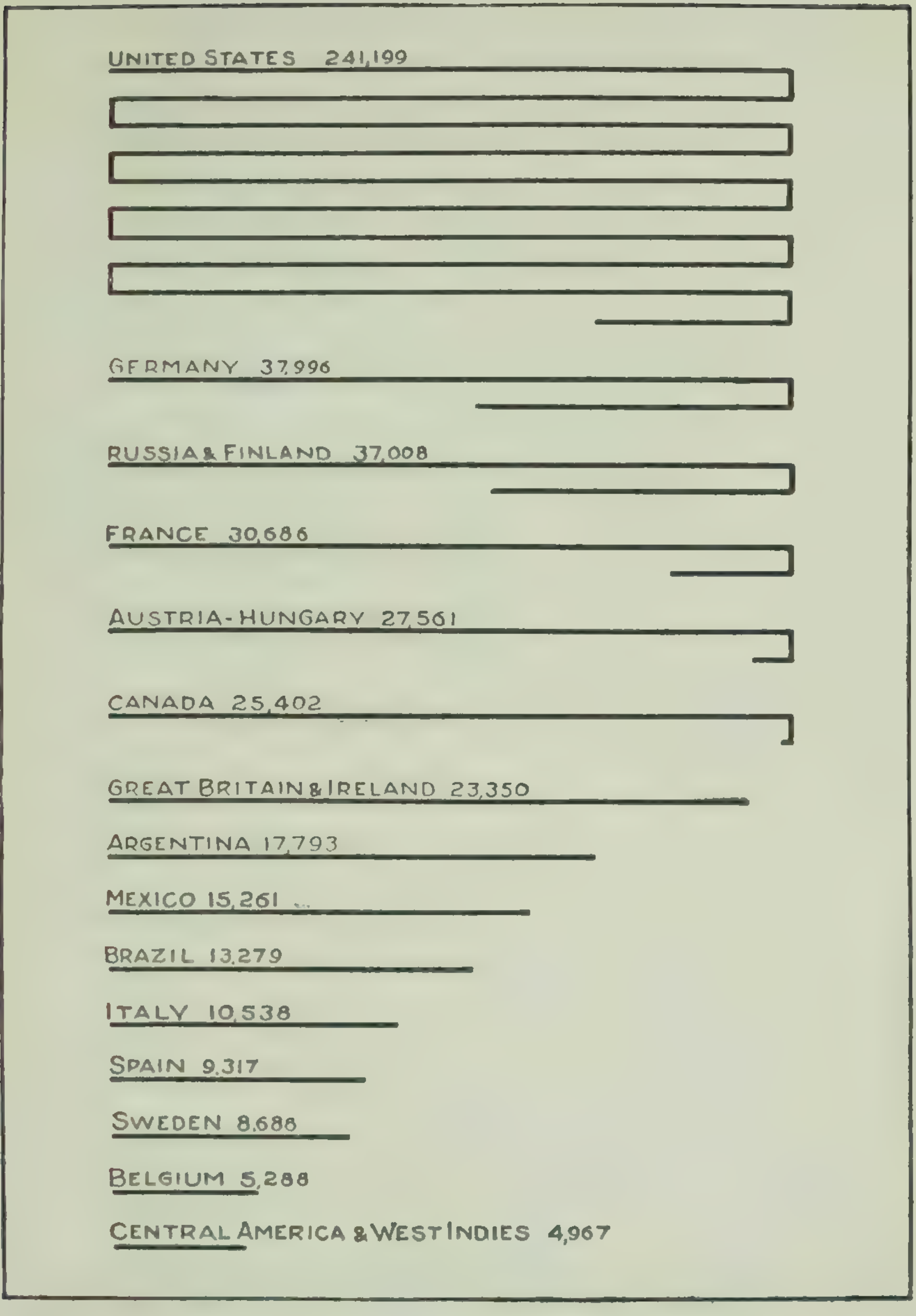


FIG. 34. RAILROAD MILEAGE OF THE LEADING NATIONS PRIOR TO THE WORLD WAR

(Constructed from a statistical table.)

Range bars. Figure 35 illustrates the use of horizontal bars in showing comparative ranges of values. The groups in this case are high school and university classes. The comparison is based on their relative standing in a test of chemistry. The scale, in percentage, ranges from zero to 100, the limits being indicated by heavy lines, and the intervals by thinner guide lines. The length of each bar represents, for a given school, the range of scores. For example, the highest group ranges from 32 to 93; the next highest, from 39 to 85; the lowest, from 5 to 91. The order in which the schools are arranged is based on the *median* score of each, indicated on each bar by a heavy vertical line near the center, projecting slightly above and below. The median scores, beginning at the top, are 69, 68, 68, 64, etc. The median does not occur in the exact center of the range, because it is based on the *number of cases*, rather than the size of the scores, as would be the case if the arithmetic mean were used. On the left side of the median line is shown a thinner projecting line, representing the *first quartile;* to the right of the line is shown the *third quartile.* The distance between these lines indicates the range of scores for the *middle fifty per cent* of the cases.

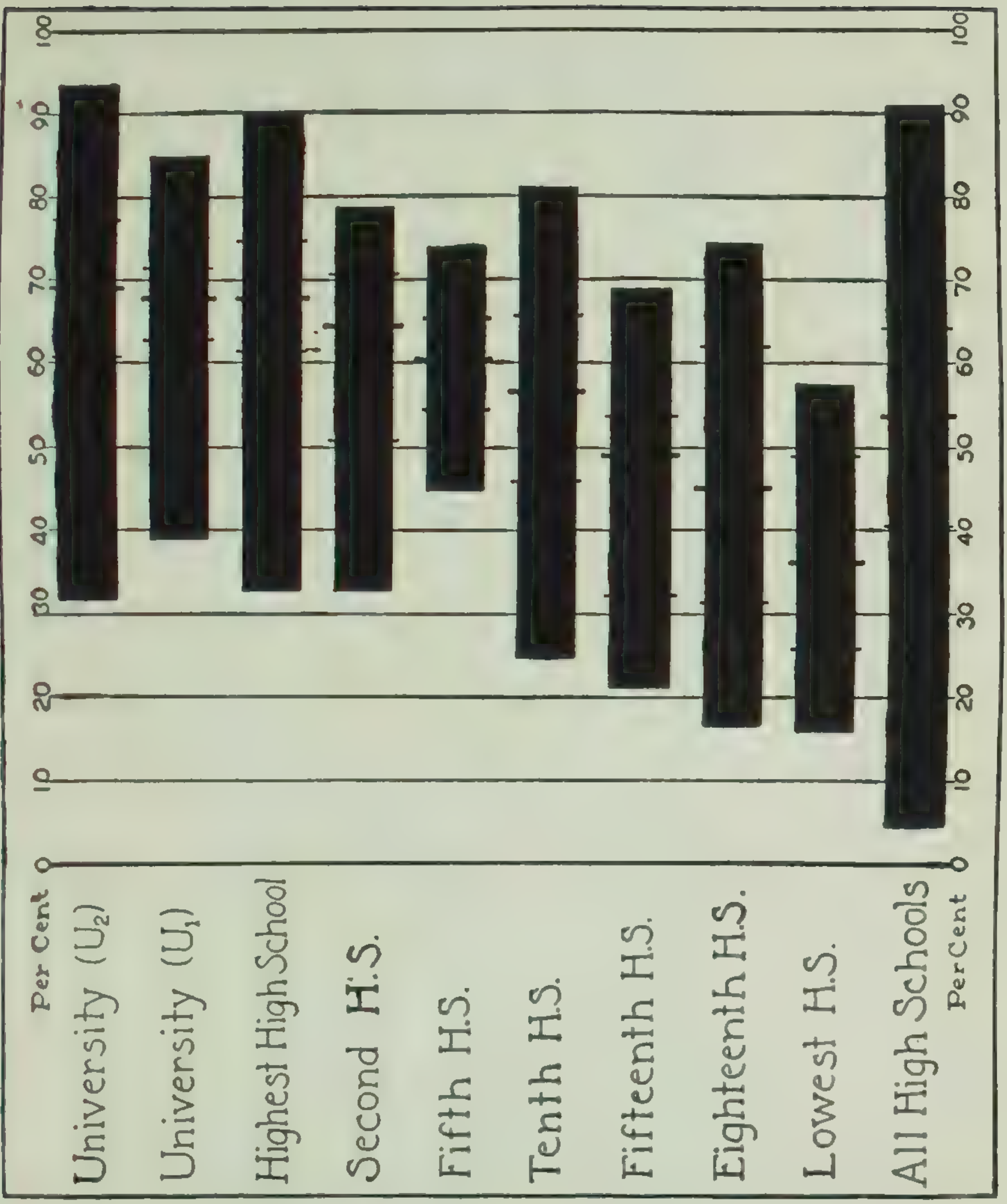


FIG. 35. SCORES OBTAINED BY SEVERAL HIGH-SCHOOL GROUPS IN A CHEMISTRY TEST

(After S. R. Powers, in *Journal of Educational Research*, November, 1922.)

Percentage range bars. In the foregoing chart each bar represents an actual frequency range of scores, which necessarily varies for different schools. In Figure 36, which is also a range chart, the ranges are reduced to percentages, and the comparisons are made on that basis. In this case the five schools are compared with regard to the results of mental ability tests. The arrangement of bars is according to average scores, the highest (104) being at the top. Each bar is broken up into segments, representing three qualities of scores; the lowest, the middle, and the highest. The segments are separated so that their lengths may be more easily compared. These separations prevent the use of a scale, which is not essential here. The data, however, are plainly indicated for each part.

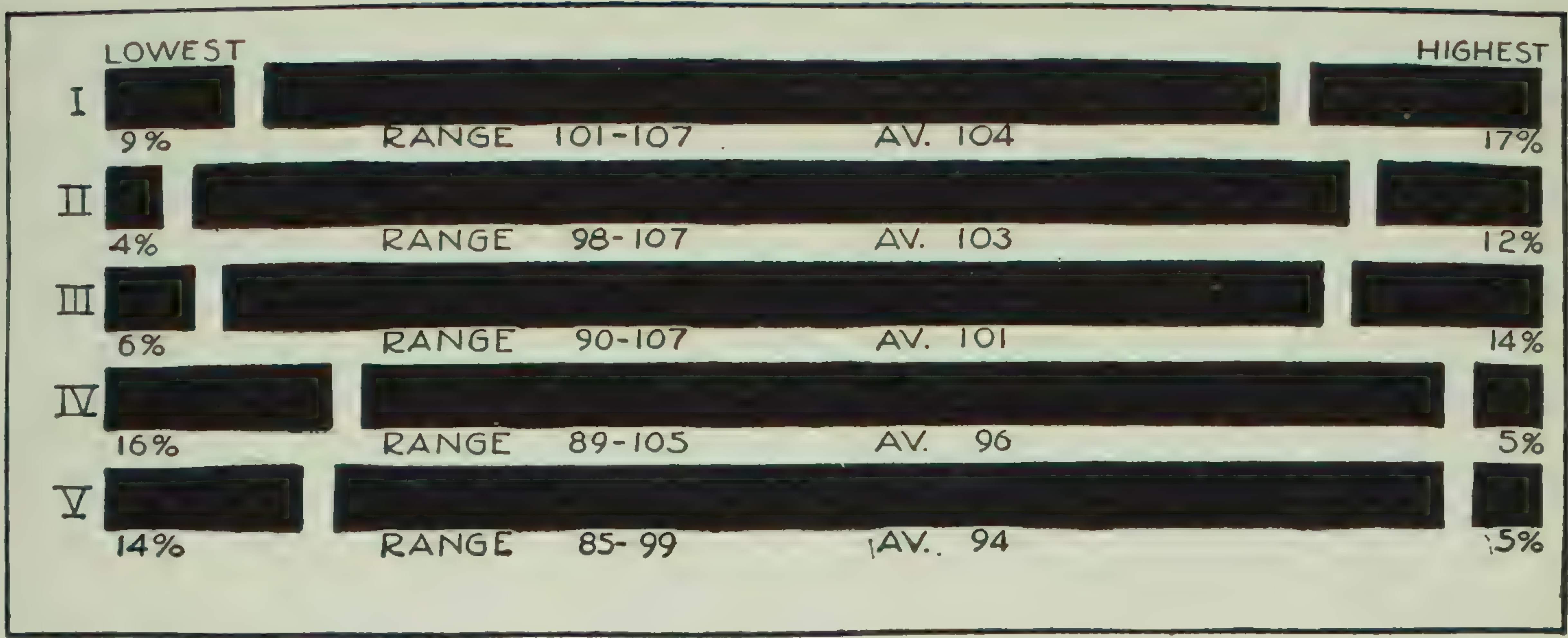


FIG. 36. DISTRIBUTION OF THE EXTREMES OF MENTAL ABILITY IN FIVE SCHOOLS
(After Rose G. Anderson, in *Journal of Applied Psychology*, March, 1922.)

Middle range bars. In the two preceding charts each horizontal bar represents a complete range of scores for a group. The median score and the middle half of the cases were also shown, but in a subordinate manner. In Figure 37 the length of each bar represents the *middle half only*, regardless of the range embodying the highest and lowest scores. The left end of the bar is the first quartile; the right end, the third quartile. The median is shown by a single short line drawn vertically through the bar near, but not always at, the center.

The chart represents the results of intelligence tests given in the Army, according to occupational groups. The groups are arranged in order of median score. At the bottom and top of the chart is the scale on which the tests were scored, in divisions of A, B, C, and D classifications. The actual scores are in points, and these are proportionately represented by the amount of space allowed for each classification. The exact point scores are not indicated, the purpose of the chart being satisfactorily met by comparisons according to the lettered groups. Note that the occupations are grouped, both horizontally and vertically, by scores.

This chart shows at a glance the practical use to which the Army tests were put. The correlation between intelligence and life-achievement is apparent. This classification was found to be a very effective aid in placing men in the type of work which they were best fitted to do.

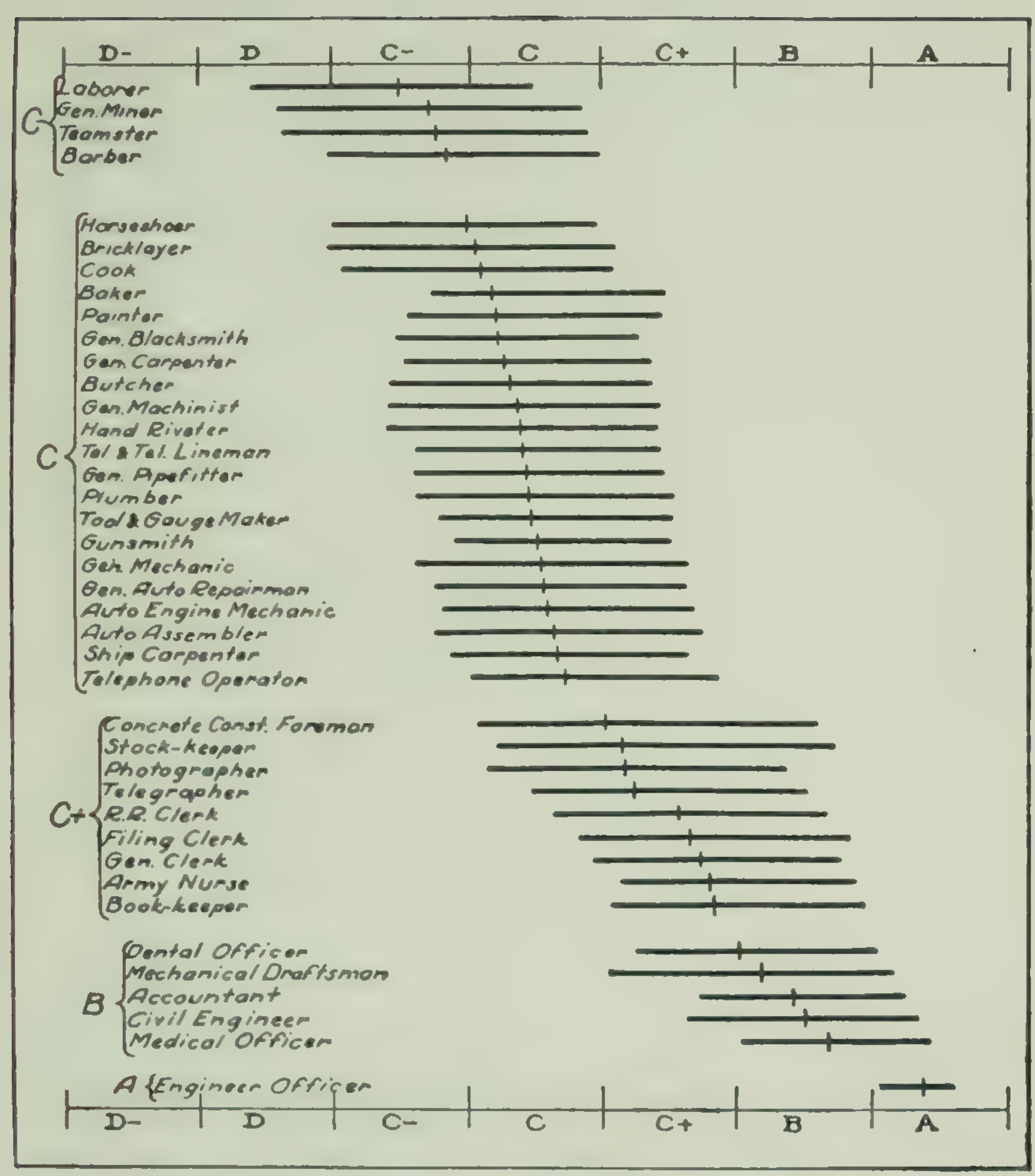


FIG. 37. ARMY TEST SCORES AND CIVIL OCCUPATIONS
(After C. S. Yoakum, in *Journal of Personnel Research*, May, 1922.)

Time ranges. Figure 38 illustrates the use of horizontal bars for showing a range of time units. The units in this case are years, referring to the ages of children. The length of each bar indicates the ages between which a given game is suitable. The stages of physical development and muscular coördination are plainly shown in the progress from wood blocks to hand ball and tennis. Some games are longer-lived than others, and some, including the rope swing and see-saw, cover the entire elementary-school period. There is considerable overlapping throughout the series. This chart, from a recent practical book for school principals, shows how the graphic method may be of value in administrative work. The availability of such data in schools will help teachers and principals to keep in mind the developmental facts upon which the equipment and supervision of efficient schools are based.

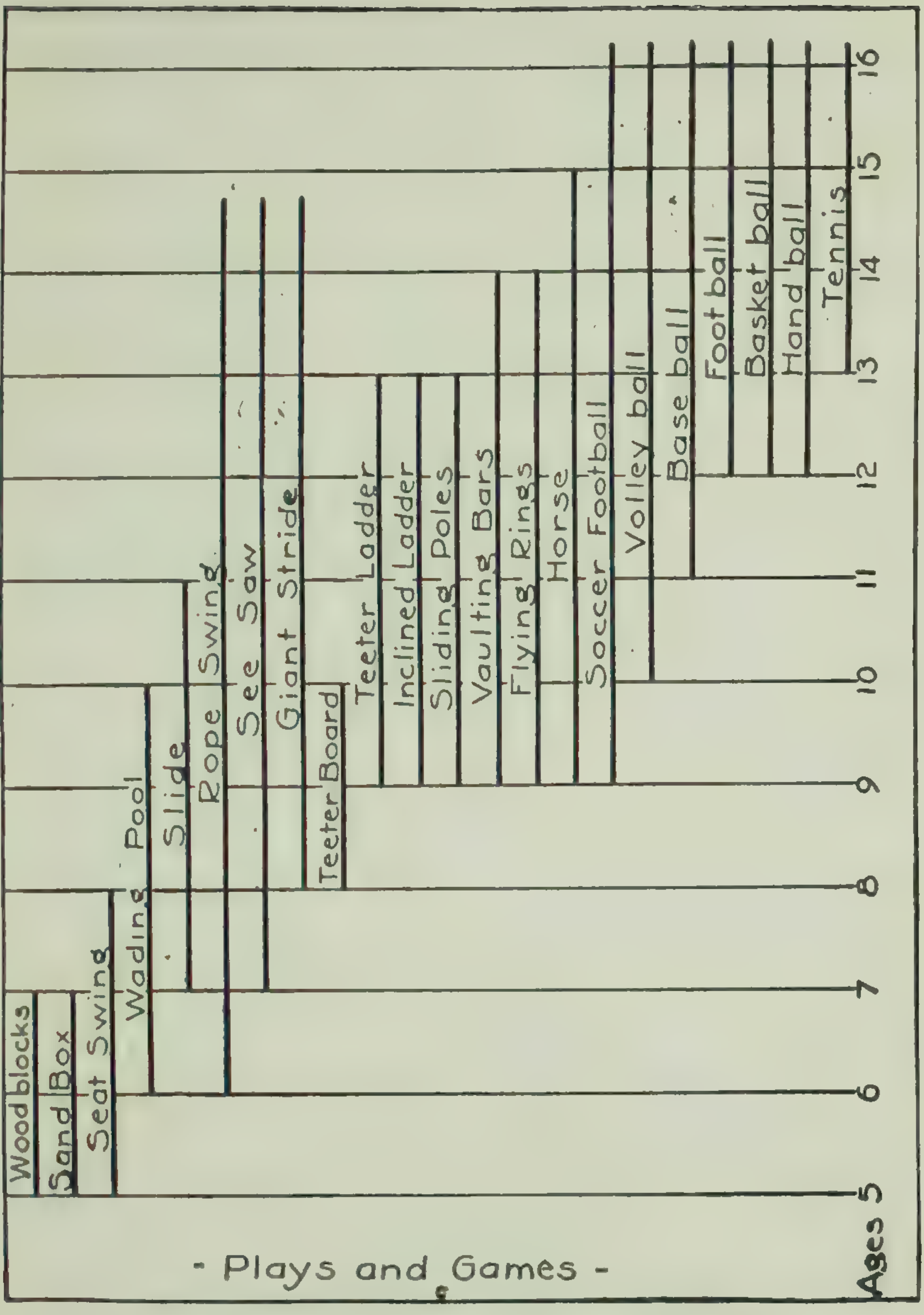


FIG. 38. AGE PERIODS FOR PLAYS AND GAMES
(From *The Principal and His School*, by E. P. Cubberley.)

Two-way horizontal bars. Two groups are sometimes compared by means of horizontal bars running in opposite directions, as in Figure 39. The population of Butte, Montana, is represented by a series of bars, representing age-groups, running from left to right from a vertical base line. A similar series of bars, running toward the left of another base line, show the population of the United States, distributed according to the same age-groups. The ages are placed between the two base lines. Two percentage scales are shown, each constructed from its own base. The bars are single-hatched, which causes them to stand out, and which is less prominent than solid black filling. The choice in such a matter rests with the chart-maker.

The two-way chart is not to be recommended for general use, because of the difficulty in making comparisons between opposite bars, as for example the two bars representing the age-group 25 to 44. The bar on the right is considerably longer, but this is not as apparent to the eye as would be the case if the bars ran in the same directions from the same base.

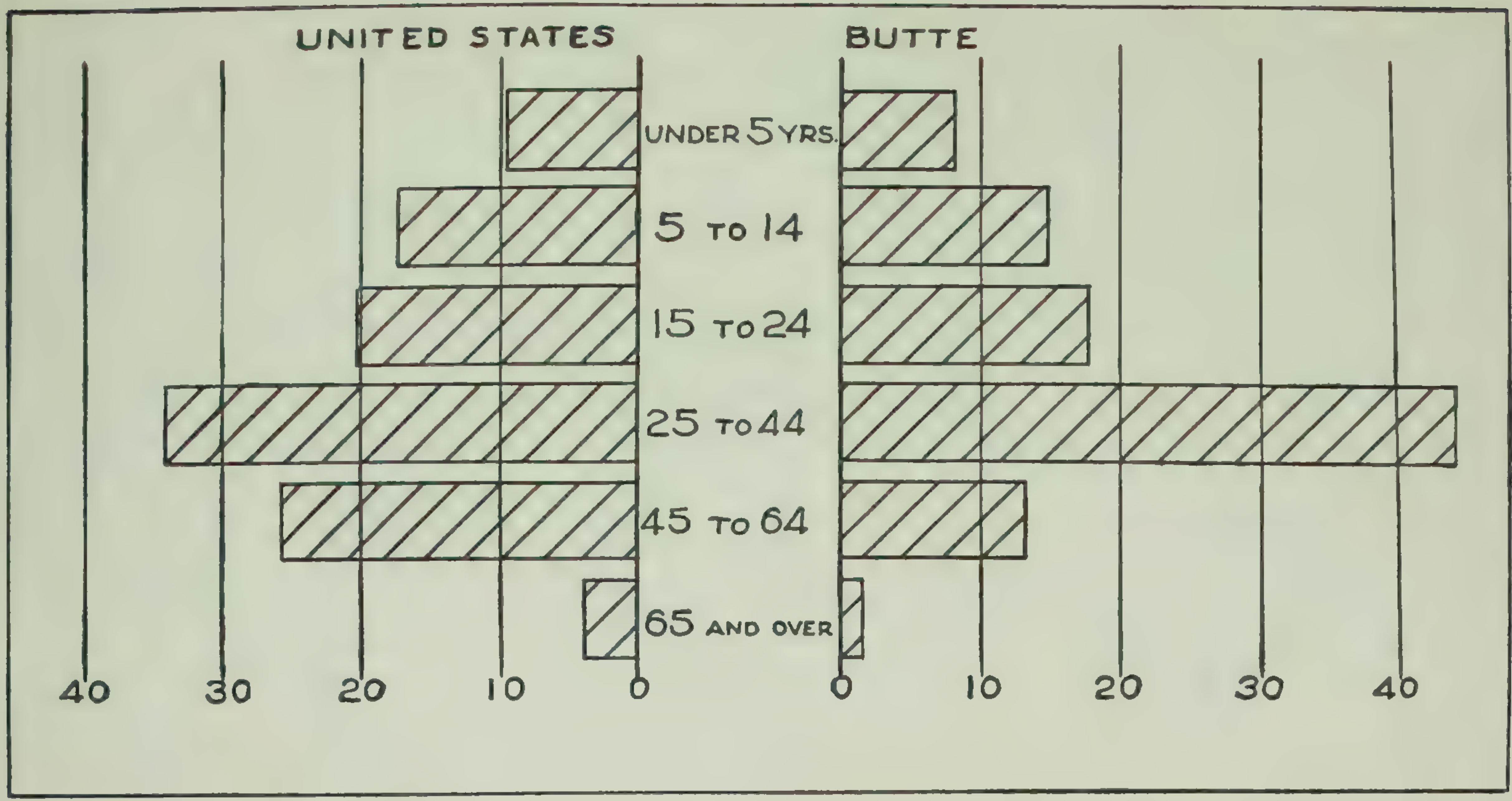


FIG. 39. AGE DISTRIBUTION OF THE POPULATION OF BUTTE, MONTANA, 1910
(Data from *The Butte School Survey*, by G. D. Strayer, and others.)

Another type of two-way horizontal bar. Figure 40 illustrates another type of two-way horizontal comparison. The chart shows the salaries of teachers in Boise, Idaho, for 1917, 1918, and 1919. The salaries are arranged in groups from \$401–\$500, at the bottom, to \$2101–\$2200, at the top. The salary groups are separated by heavy horizontal lines, and each group is divided into the three-year periods, which in turn are separated by lighter lines. Elementary-school salaries are represented on the right, and high-school salaries on the left. A frequency scale is shown at the bottom for each direction, from which the number of teachers receiving each salary may be found. Guide lines are ruled in intervals of one, so that each of the small filled squares represents one teacher. For example, salaries ranging from \$1201 to \$1300 were paid, in 1919, to six elementary- and five high-school teachers; in 1918, to three elementary- and one high-school teacher; and in 1917, to three elementary- and two high-school teachers.

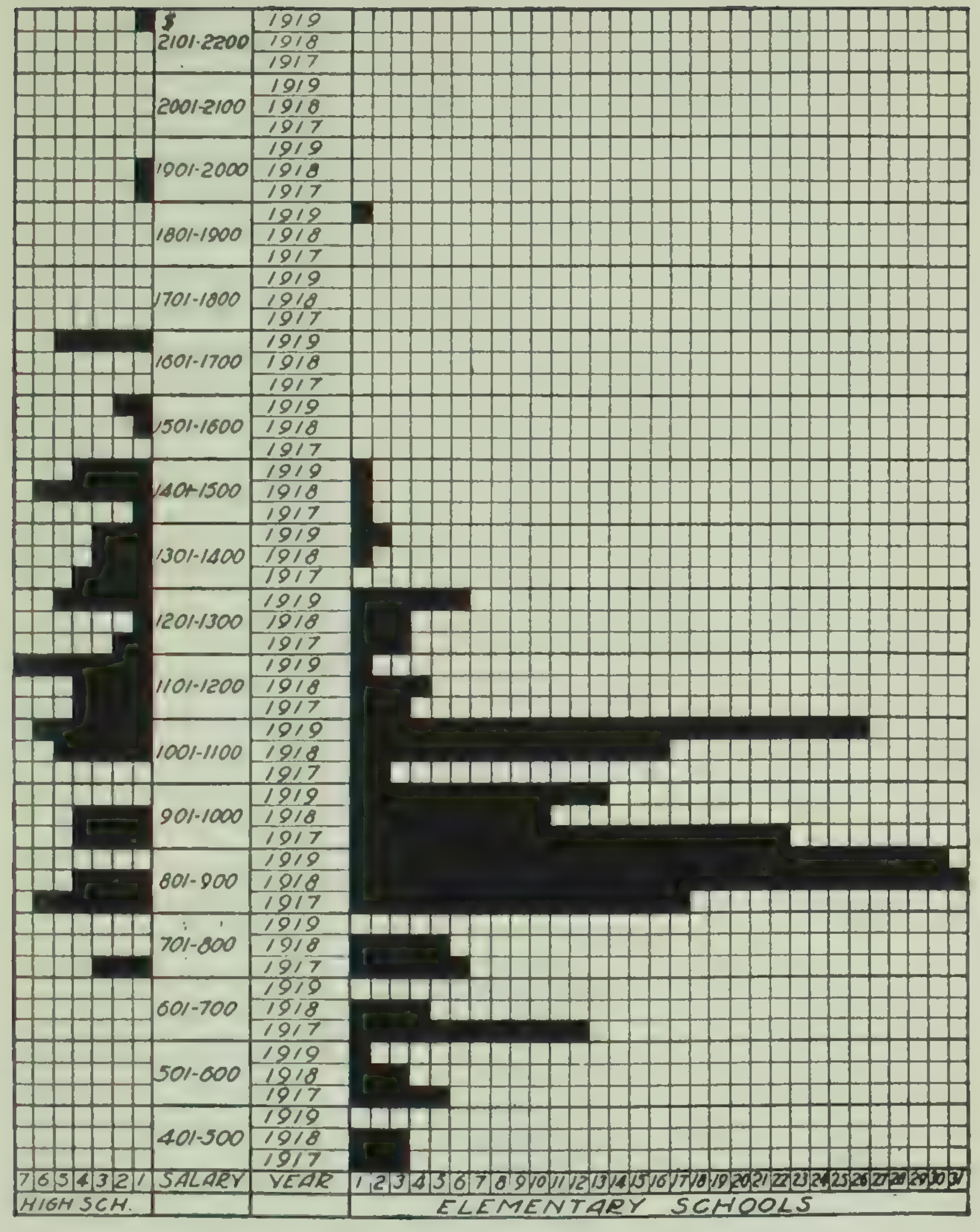


FIG. 40. DISTRIBUTION OF TEACHERS' SALARIES IN BOISE, IDAHO, FOR THREE YEARS

(From *The Boise Survey*, by J. B. Sears.)

2. *Vertical bar charts*

Vertical bars; simple. The remaining charts in this chapter illustrate the use of vertical bars, or columns, standing on a horizontal base. The bars are of the same width, and their respective lengths, measured from the base line, represent the value under consideration. A simple form of this type of chart is shown in Figure 41. Each bar represents the rate of hookworm infection in a southern county for one year. Only three years are shown; 1910, 1911, and 1921. The purpose of the chart is to show the decrease in rate during the eleven-year period. The bars are drawn according to a uniform scale, which, however, is not shown, because of the simple character of the chart. The exact data are given at the base of each column, together with the idea represented, namely, *rate of infection.*

This chart was used in connection with one of the annual reports of the Rockefeller Institute, and tells in a vivid manner the remarkable effectiveness of one phase of their work.

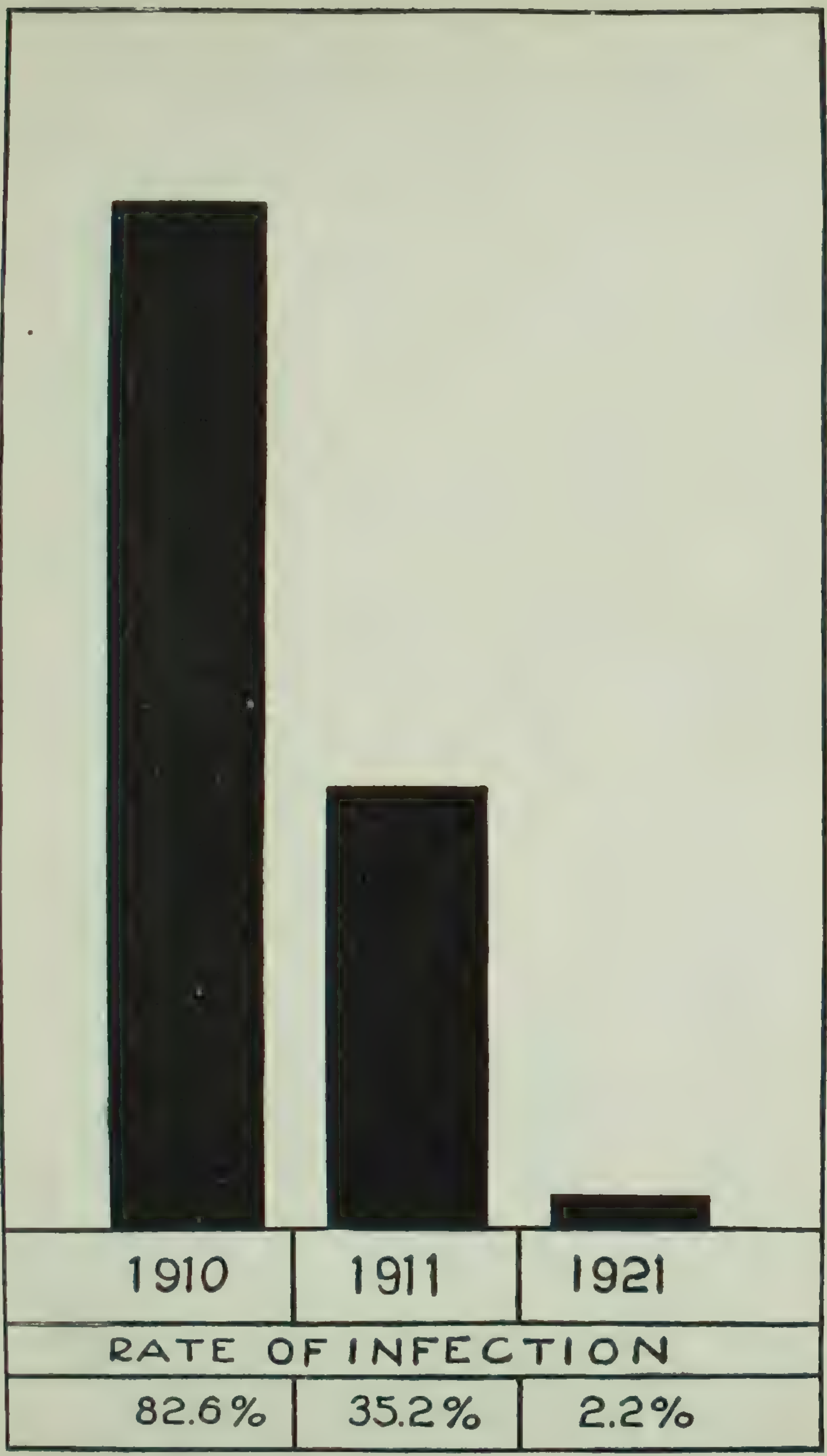


Fig. 41. The "Hookworm Story" of a Virginia County as a Result of Health Work under the Rockefeller Foundation

(From *Annual Review* of the Foundation. 1921.)

Another simple form of vertical bar chart. Figure 42 shows the commonest form of vertical bar charts. The bars represent the causes of infant deaths in the United States, for one year. The tallest column, representing natal and prenatal causes, is shown at the left. The other causes are arranged in decreasing order, excepting the last column, which is based on the total of all causes other than the four shown at its left. This column, according to its height, might seem to belong fourth in order; but it really represents a number of causes, no one of which is equal in frequency to the epidemic group. Because of the impracticability of representing each of these separate causes, and in view of their relative unimportance, it is more efficient to group them into one column, placed in the position of least emphasis.

The vertical frequency scale, shown at the left, ranges from zero to 70,000. The placing of the word "thousands" at the top permits the use of smaller numbers in the scale. Thus 10 represents 10,000; 20 represents 20,000; etc.

Graphic methods for presenting such data are frequently used to good advantage in Government publications, from one of which this chart is taken.

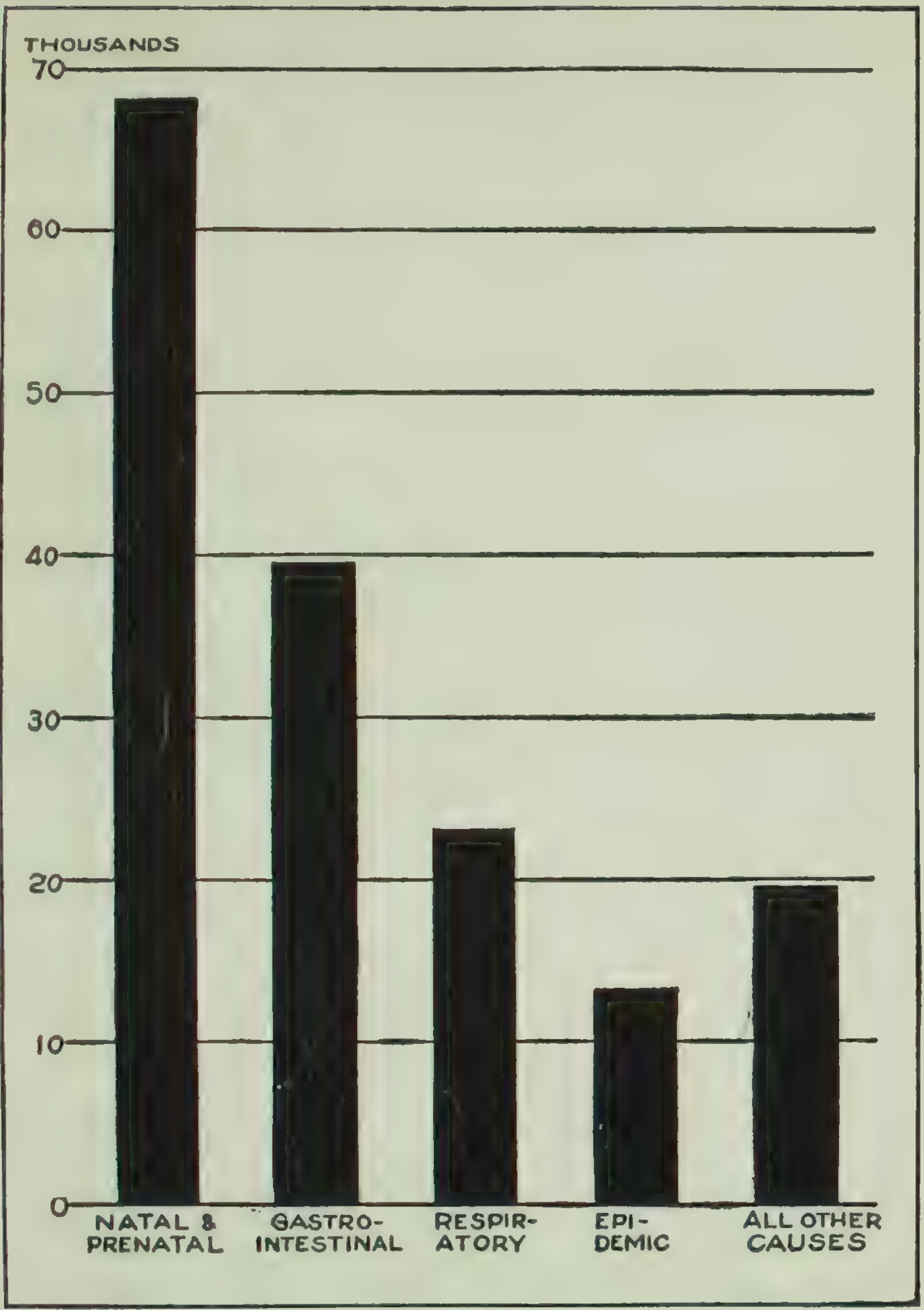


FIG. 42. INFANT MORTALITY DATA FOR 1916 IN THE UNITED STATES REGISTRATION AREA, GROUPED BY CAUSES

(From a Bulletin of the United States Department of Labor.)

Time-distribution charts. How values distributed unevenly through the year may be shown by vertical bars is illustrated in Figure 43. This chart represents the average rainfall of a California county, distributed by months. Each bar represents one month. The order of presentation is not by frequency, but according to the sequence of the months. By frequency the chart would show first January, then March, then December, which order would not tell us so plainly just what happens during the course of the year. The amount of rainfall, in inches, is indicated by the height of the bar, which accords with the prevailing scientific method of measuring rainfall. For this purpose vertical bars are obviously superior to horizontal bars. The scale is shown at the left, with the base line at the bottom, and horizontal guide lines representing intervals of one inch. The highest guide is at 5 inches, which is the first whole number beyond the height of the tallest column. The exact data are given underneath the bars. Note how the chart shows the rapid decline after the period of heavy precipitation.

This chart was used in the report of a county rural school survey, in connection with a discussion of climatic and economic conditions which were considered important factors in the educational reorganization proposed.

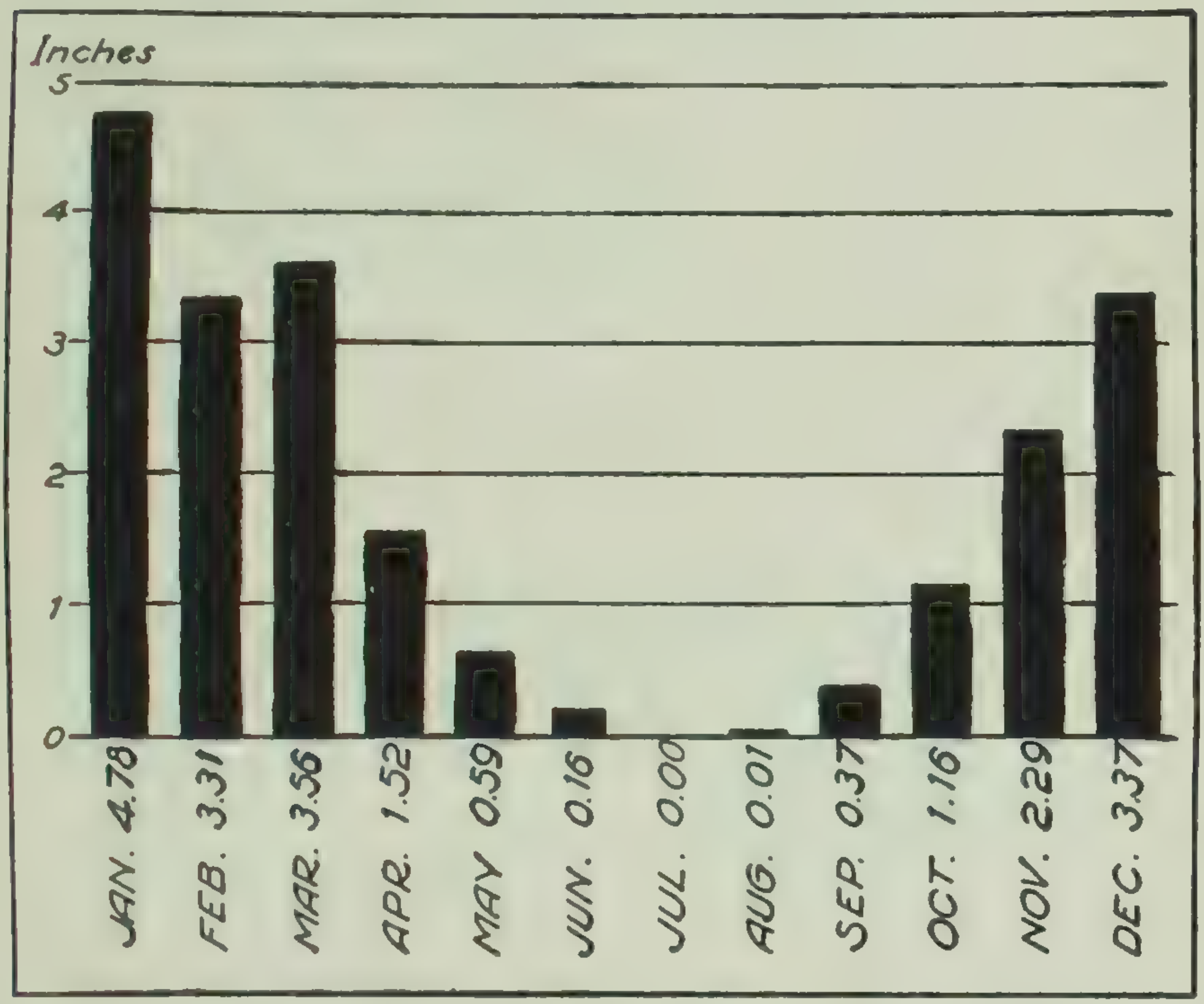


FIG. 43. DISTRIBUTION OF RAINFALL IN SAN MATEO COUNTY, CALIFORNIA
(From United States Bureau of Education Bulletin no. 16. 1916.)

Time-distribution chart, broken series. Figure 44 is constructed exactly like the previous chart. In this case the columns represent the number of cases of truancy each month in an Ohio city. Note the rapid increase toward the end of the school year. The number of cases is small, which probably accounts for the irregularity in the size of the shorter columns. However, the seasonal aspects of school attendance are vividly brought out. The reports of the attendance officer were discontinued in July, and were not resumed until November, hence the space representing the intervening months is marked "no report." If this were not done it might be inferred that there were no cases of truancy during that time. Such matters are often overlooked in chart-making, with the result that the charts lead to incorrect conclusions.

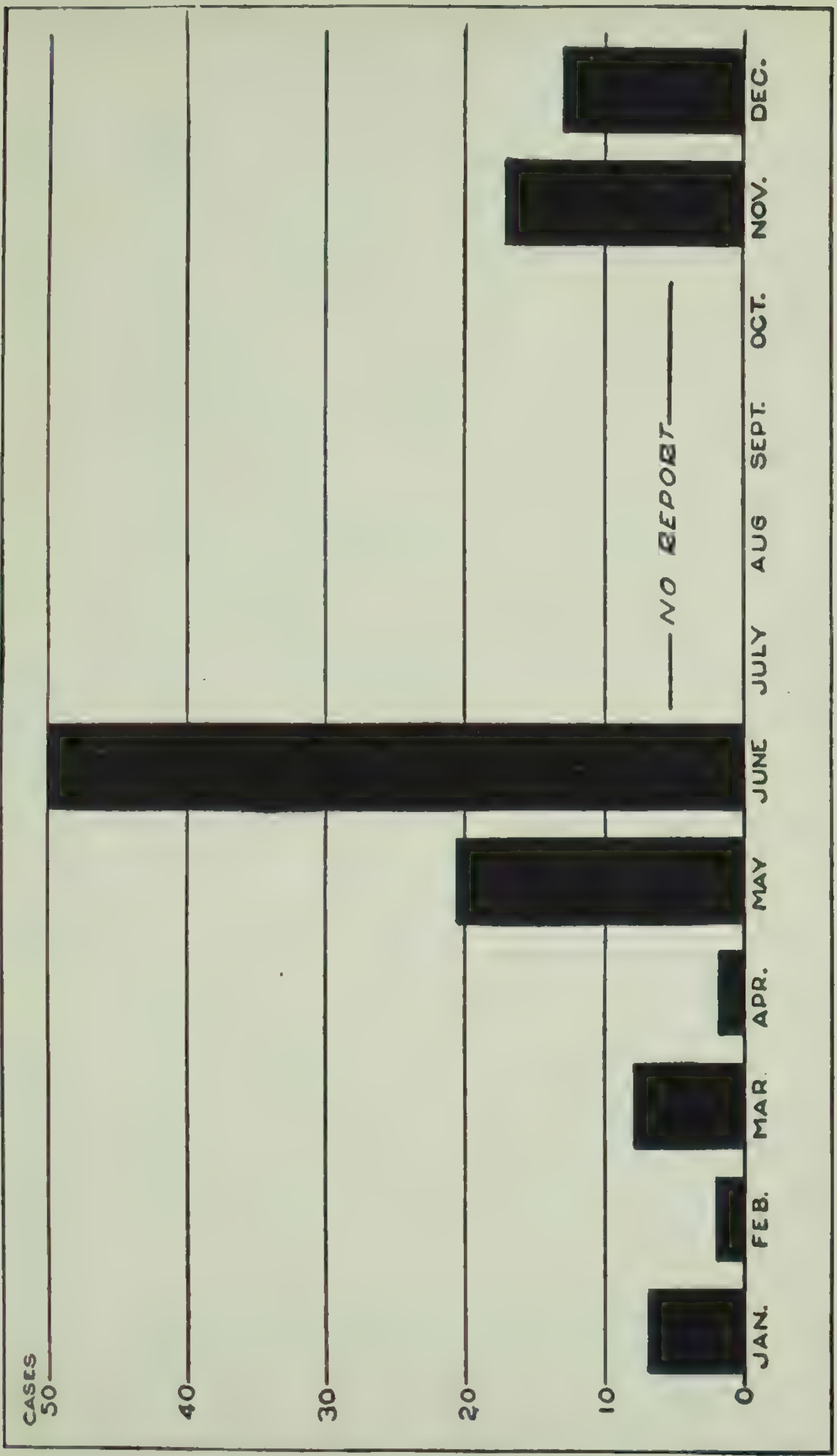


FIG. 44. CASES OF TRUANCY REPORTED FOR ONE YEAR BY THE PUBLIC SCHOOL ATTENDANCE OFFICER IN ELYRIA, OHIO

(Data from United States Bureau of Education Bulletin no. 15. 1918.)

The "torn segment" distribution chart. Figure 45 shows the distribution of working hours for women in a Southern State. The number of hours per week ranges from 44 to 69. The vertical scale is constructed at the left in intervals of one so that each space represents one per cent of the cases. The total length of the bars, if placed end to end, would be 100 per cent. The distribution is irregular, but reaches significant peaks at 55 and 60 hours. Inasmuch as the tallest bar is but 31 per cent in height, the guide lines extend only to 35, which is a convenient number. Instead of showing all of the blank space between 35 and 100 on the vertical scale, making the chart three times its present size, the heavy 100 per cent line is shown on a segment which is made to appear torn from the chart and separated slightly from it. This is the standard procedure for percentage charts, the effect being produced by means of wavy lines. This warns the reader that the proximity of the bars to the top of the chart is not to be taken as the extent to which they approach their limit.

In laying out the spaces for the hour intervals, allowance was made for a narrow space between the bars, so that each might stand out distinctly.

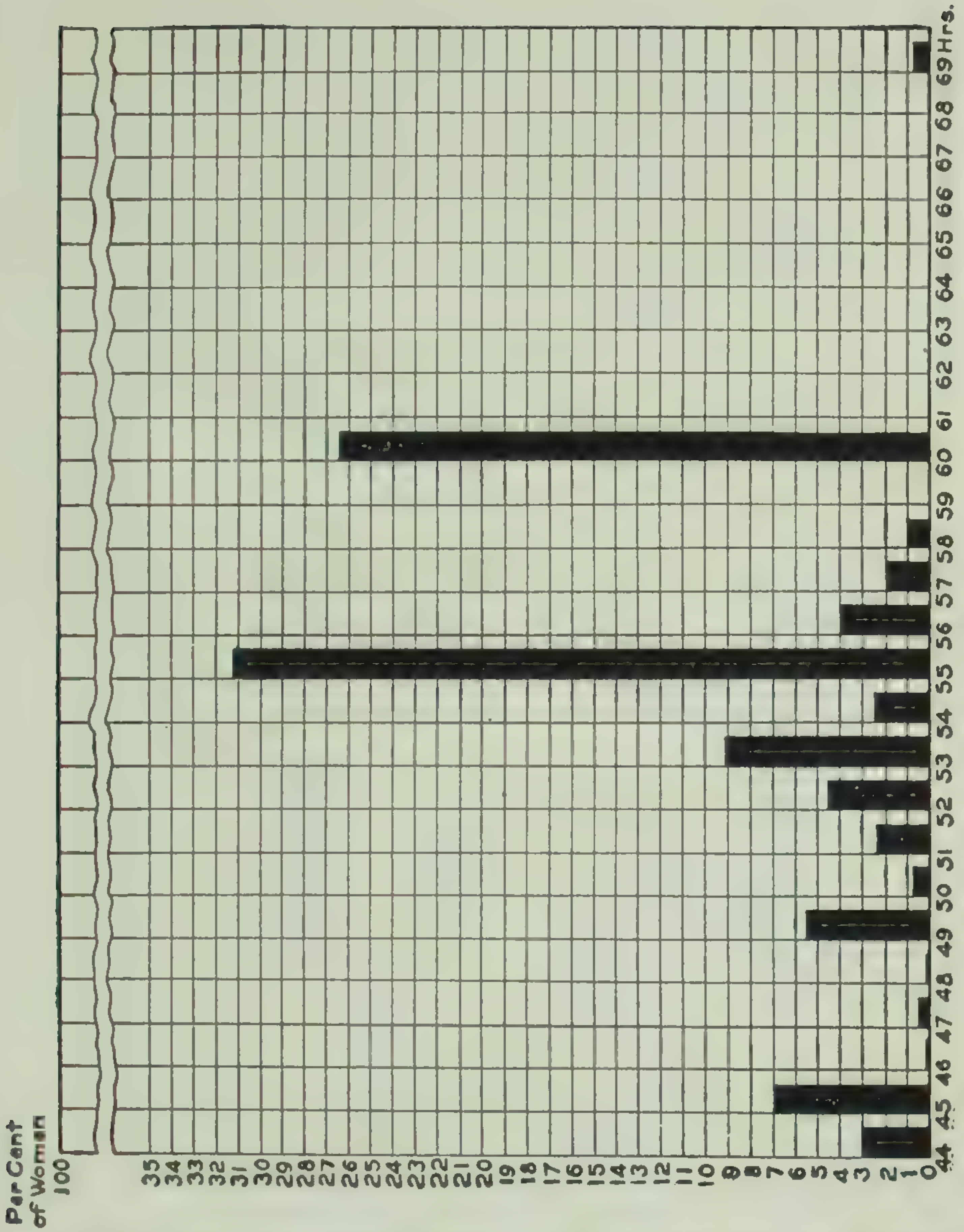


FIG. 45. SCHEDULED WEEKLY WORKING HOURS FOR WOMEN IN GEORGIA
(From United States Women's Bureau Bulletin no. 22. 1922.)

Comparative-group vertical bars. Figure 46 is intended to show how a school principal, through an intensive drive against retardation, brought about a marked improvement in his age-grade distribution in five years. Beginning with nearly 25 per cent retardation and but 2 per cent acceleration, he reduced the former to 12 per cent and increased the latter to 9 per cent. For each year a double column is shown, retardation being represented by a black area, and acceleration by a white area. These symbolize respectively undesirable and desirable qualities. The years are indicated at the bottom, reading from left to right. The key, or legend, which is a necessary part of such a presentation, is placed in a convenient empty space, where it does not increase the size of the chart. The accelerated areas might have been hatched lightly, if thought more desirable in bringing out the presentation.

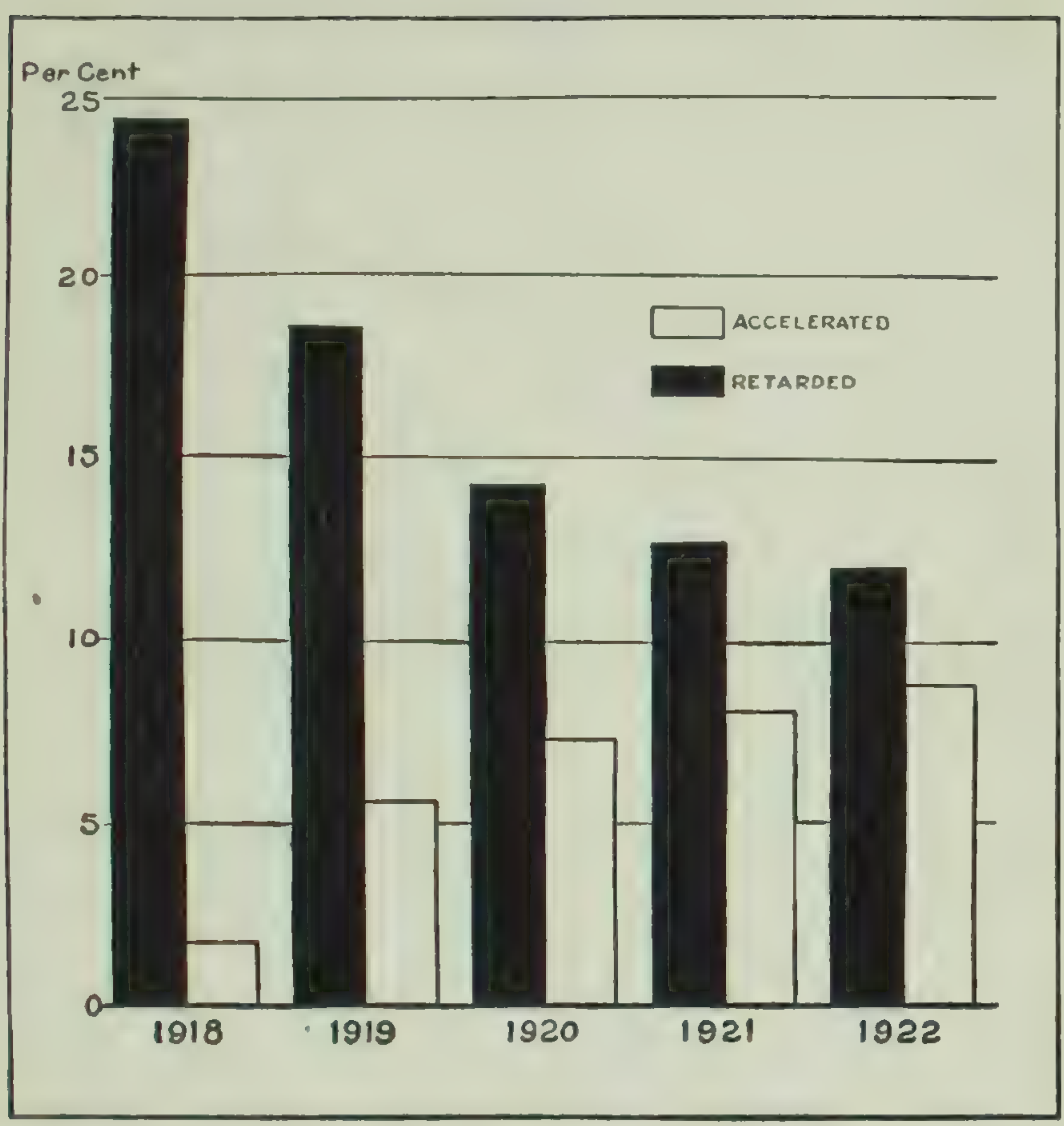


FIG. 46. RESULTS OF A FIVE-YEAR STUDY OF PUPIL PROGRESS IN A CITY SCHOOL

(From *The Principal and His School*, by E. P. Cubberley.)

Charts showing more complex relationships. Figure 47 illustrates the use of shaded areas in a more complex manner than in the previous chart. The purpose of the chart is to show the apparent effect of education upon the introduction of modern conveniences in a middle-western State. Four groups of farmers are shown, according to their education: first, those who have completed only the common school; second, those who have taken a short course in agriculture; third, the high school group; fourth, the college group. In each of the groups appear four columns, representing lighting systems, bath rooms, furnace heat, and automobiles. A type of shading is chosen for each, and is plainly indicated by the key. The height of each bar represents the percentage of persons having the convenience. For example, bath rooms have a frequency of 17 per cent for the common school group, 22 per cent of the "short course" group, and 44 per cent of the college group. The chart does not tell us, of course, how much of this improvement is actually due to education, but the relation between the two sets of facts is obvious.

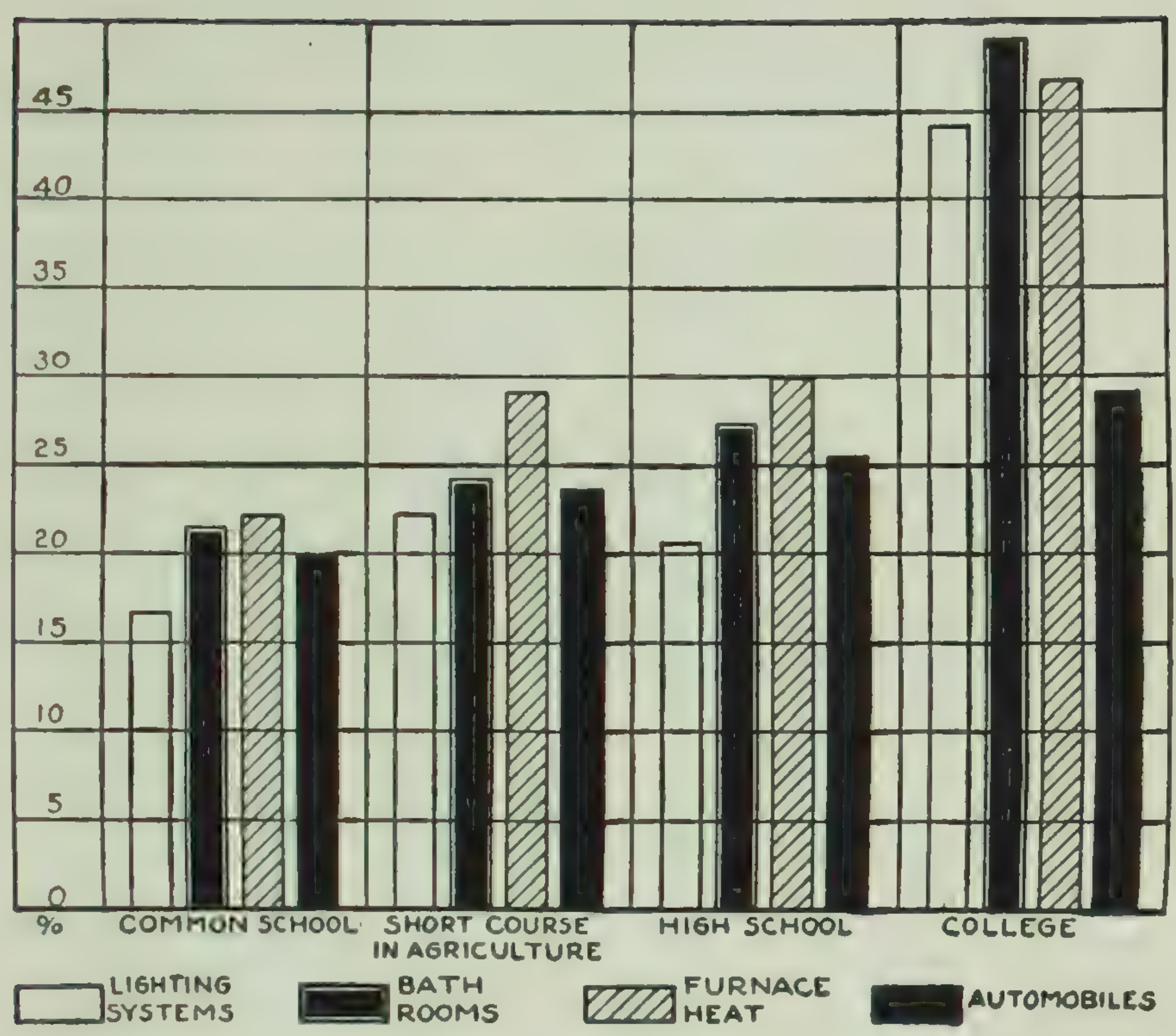


FIG. 47. RELATION BETWEEN EDUCATION AND USE OF MODERN CONVENIENCES IN A MIDDLE-WESTERN STATE

(From a bulletin of the University of North Dakota.)

Two-way vertical distributions. Figure 48 illustrates the use of vertical bars running above and below the base line. Each bar, in both directions, represents a group of policemen for a given period of service. The zero group, indicated at the left, includes new men, or candidates for appointment. The second group includes men who have served from one to two years; the third group, three to six years; etc. The bars extending above the base line represent the percentage of men in each group who were found to be above average in mental capacity. The bars extending below the base line represent the men who tested below average. It is clear that the average intelligence of the newer men is higher than that of the men who have been in service many years, this inverse relationship being consistently true throughout the groups.

Note that the top and bottom guide lines are used as a part of the border. This is not essential, but it saves space. The scale extends in each case to the next round number beyond the end of the longest bar. Note that the upper scale is three times the length of the lower.

FIG. 48. RESULTS OF ARMY INTELLIGENCE TESTS OF CLEVELAND POLICE OFFICERS, IN RELATION TO LENGTH OF SERVICE

(After L. L. Thurstone, in *Journal of Personnel Research*, June, 1922.)

PROBLEMS FOR CHARTING

1. Construct a simple horizontal bar chart from the following data:

NORMS FOR THORNDIKE DRAWING-SCALE

Grade	1	2	3	4	5	6	7	8
Score	5.8	6.7	7.8	8.0	8.3	9.1	9.0	9.1

2. From additional United States Census data, reconstruct Figure 29 to include the data for 1870, 1860, and 1850.
3. Reconstruct Figure 31, making bars Numbers 6, 9, and 16 somewhat thicker and bolder, with spacing that will more plainly indicate that they represent summarized data.
4. From the *Boise Survey*, p. 195, construct a chart similar to Figure 33, but showing the relative standing of the schools with regard to the efficiency of classrooms. (Item IV in the scale.)
5. Reconstruct Figure 37, reversing the order, so that the highest score will be at the top and the lowest at the bottom.
6. Following the plan of Figure 38, construct a chart to show the types of stories suitable for children according to age levels.
7. From 1920 United States Census data construct a chart for your own city, following the plan of Figure 39.
8. Construct a rainfall chart for your own county, patterned after Figure 43.
9. Construct a chart patterned after Figure 47, from the following data:

CAUSES OF DEFORMITIES IN CHILDREN

CAUSE	LONDON (per cent)	GERMANY (per cent)
Tuberculosis	49.9	15.0
Paralysis	28.7	14.8
Congenital	7.0	8.6
Rickets	4.8	6.3
Scoliosis		12.2
Miscellaneous	9.6	43.1

CHAPTER V

CIRCLE REPRESENTATIONS

(EXPLAINING FIGURES 49 TO 59, INCLUSIVE)

General definition. This chapter is concerned with the illustration of charts which are mainly circular in form. The most important instrument needed for their construction is the compass. It is often necessary to lay out the chart with T-square and triangle, as in Practice Sheet Number 5. The instructions for adjusting and manipulating the compass should be carefully followed in order to insure good results.

Circle charts do not have to be drawn first in pencil, as required for straight-line charts. It is sometimes advisable to do so when it is desired to see the complete form and proportions of the chart; but ordinarily much time can be saved by laying off the radius and drawing the circle with ink in its final form.

For reasons which will be indicated in some of the descriptions which follow, circle charts are not highly desirable for representing facts. The circular form has long been observed to attract attention, however, and this is probably one of the reasons for its frequent use. The figures shown here are representative of the principal uses to which circle charts have been put.

Simple comparisons. Figure 49 shows a series of five circles, arranged in order of size from right to left, and constructed so that they stand on the same imaginary base line. The method of construction is as follows: a horizontal line is drawn, with the T-square, near the bottom of the chart. The relative sizes of the circles are determined by the relative values of the items. After determining the diameter, the compass is set for the radius of each circle, and the point of the compass placed at the proper distance above the base line. Allowance must be made for the proper distances between the circles. The comparison is between the *areas* of the circles. Inasmuch as the areas of circles vary in proportion to the squares of their diameters, their relative sizes are not easily ascertained by ordinary visual comparison. The fault of such a presentation is even more serious than in the case of comparative squares, as explained in connection with Figure 16.

The exact data on which the chart is based are shown on the circles, so that a purely statistical comparison is still possible. In view of the fact that the circular shape has no psychological connection with the items shown here, this comparison could be made to much better advantage by means of a series of horizontal bars.

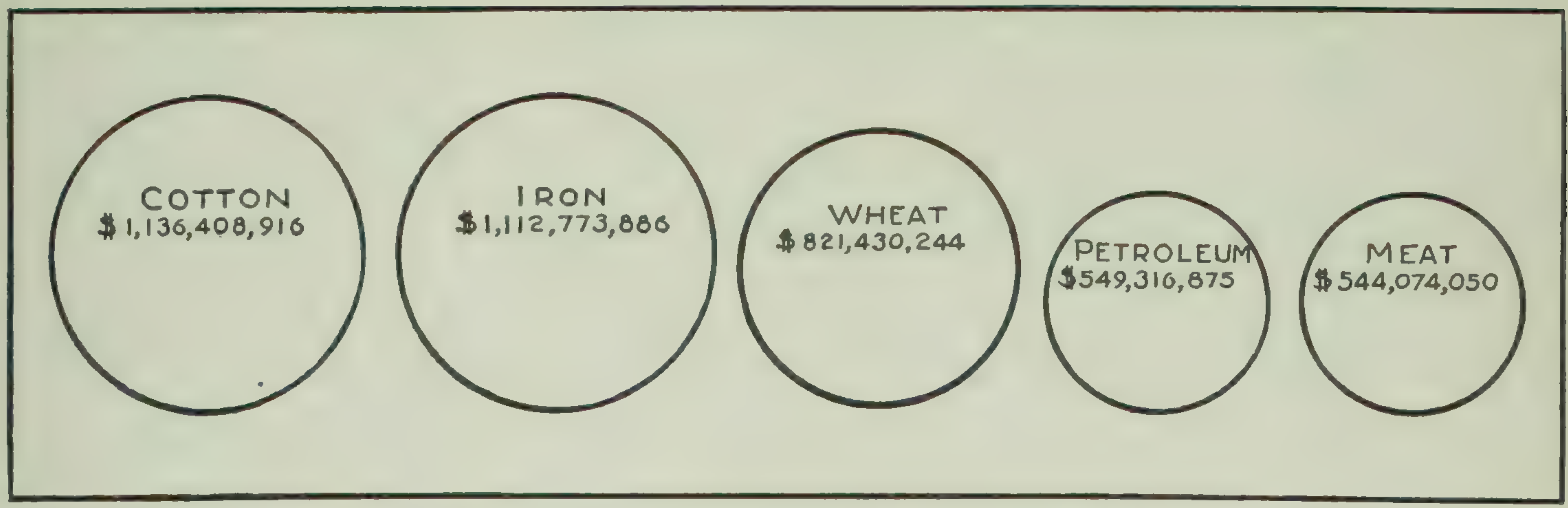


FIG. 49. FIVE LEADING EXPORTS FROM THE UNITED STATES IN 1920
(Data from *Human Geography*, by J. Russell Smith.)

Concentric circles. Figure 50 shows a series of concentric circles representing, in their areas, the population of the five largest cities of the United States, according to the 1920 Census. By placing the circles in this position it is possible to make them larger than would be the case if the form of Figure 49 were used. The relative status of Cleveland and Detroit could hardly be observed if the circles were placed side by side. This method is valid only in that it shows how the population of New York, if spread out over the population of the next largest city, Chicago, would extend far beyond the limits of the latter. The reader of such a chart is likely to gain the impression that New York is larger than all the other cities combined. This, however, is not the case, although it happens to be near the truth. It would be a greater error to assume from the chart that the population of Chicago is equal to the combined population of Philadelphia, Detroit, and Cleveland, which are shown encompassed by the Chicago circle.

It may seem that the possibility of such erroneous conclusions is remote, but it may be demonstrated by showing this chart to a number of persons who are not statistically inclined, and obtaining their first impressions.

In view of the characteristic expanding of cities with the growth of population, there is a psychological reason for using circles for such a comparison, which reason is not applicable to the previous figure. The limitations of the method, however, should be carefully considered before drawing such a chart.

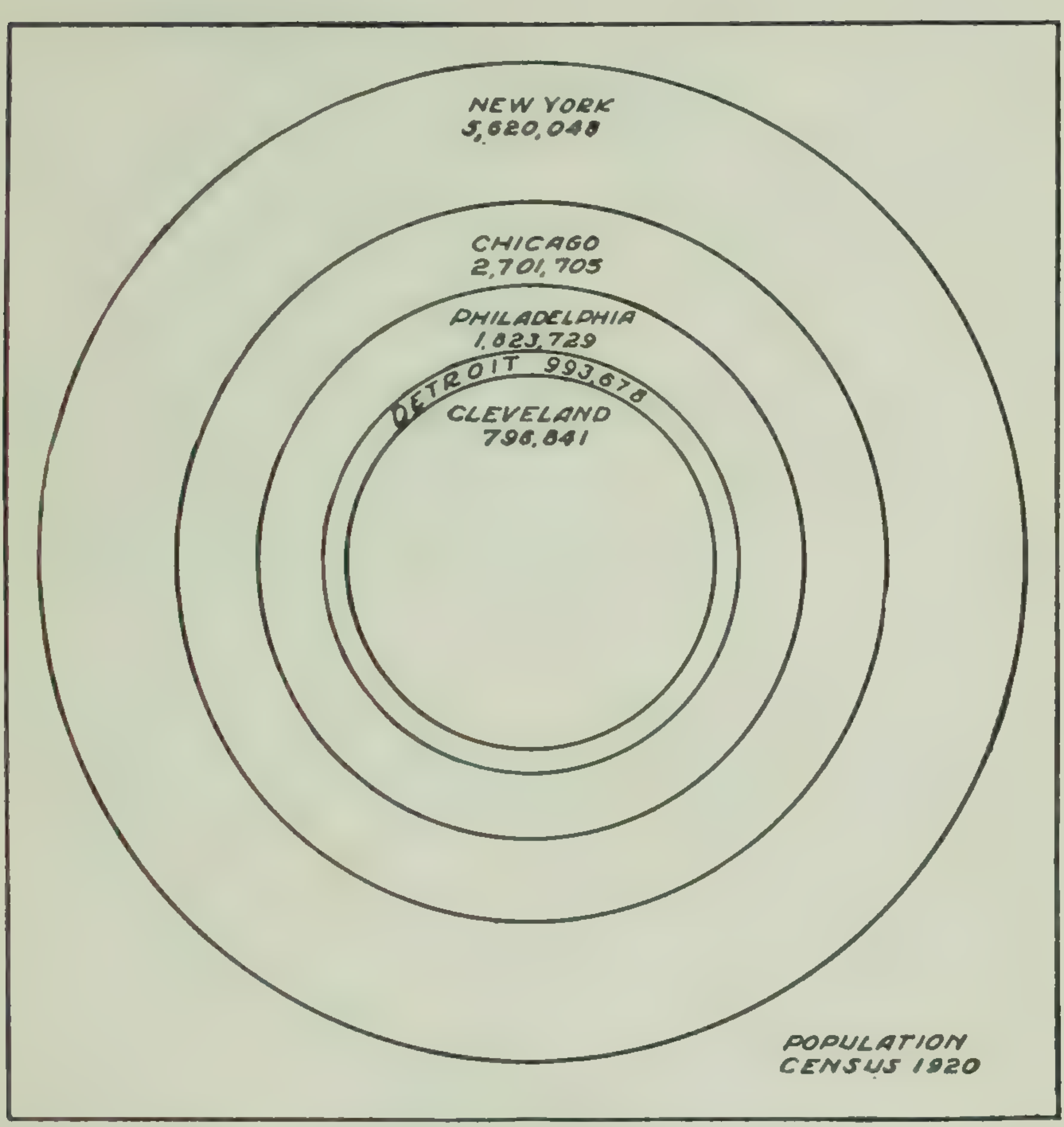


FIG. 50. POPULATION OF THE FIVE LEADING CITIES OF THE UNITED STATES IN 1920

(Data from United States Census Report, 1920.)

Sector comparisons. The *Portland School Survey* of 1914 aroused considerable interest among educators and the public in the matter of educational costs. The chart entitled "How Portland Spends Its Dollar," a form of which is reproduced in Figure 51, embraced some of the most significant findings of the Survey. Here the cost of the public schools in relation to the cost of other civic necessities was presented in a graphic form easily within the comprehension of any person. Many subsequent educational surveys included similar charts in their published reports.

The entire circle represents one dollar of the city's annual expenditure. The relative amounts devoted to the several purposes are represented by sectors, arranged in order from the largest, which in this case is EDUCATION, to the smallest, which is HEALTH. This method of showing the division of the dollar is effective, although it is subject to the errors already referred to in connection with the use of triangular areas. The chief value of the circle-sector lies in its suitability for attracting popular attention, and in the psychological association of the circle with the idea of a dollar.

In laying out the sectors of a circle, the percentage values are first reduced to degrees, and the space measured with the aid of the protractor. Each one per cent of value is represented by an arc-space of 3.6 degrees.

FIG. 51. HOW PORTLAND SPENT ITS DOLLAR IN 1914
(From *Report of the Portland School Survey*, by E. P. Cubberley and others, 1914.)

Total cost, and sector distribution, not proportioned. Figure 52 shows the expenditures of a California county, represented by sectors of a circle, following the plan of the previous chart. In this case the arrangement of the sectors is not by size, probably because the draftsman wanted the chart to be better balanced mechanically than the Portland chart. Inasmuch as comparison is the main purpose, however, the arrangement is important. Statistical data, whenever possible, should be shown in order of increasing or decreasing values.

In the center of the chart is a small circle in which is indicated the total county expenditure. The plan of showing the total amount is commendable, but this method does not convey the idea clearly. It would be better to indicate the total outside of the large circle. This chart is especially valuable in that the individual values are indicated in both actual amounts and percentages. Sector charts often leave too much to be evaluated by the reader.

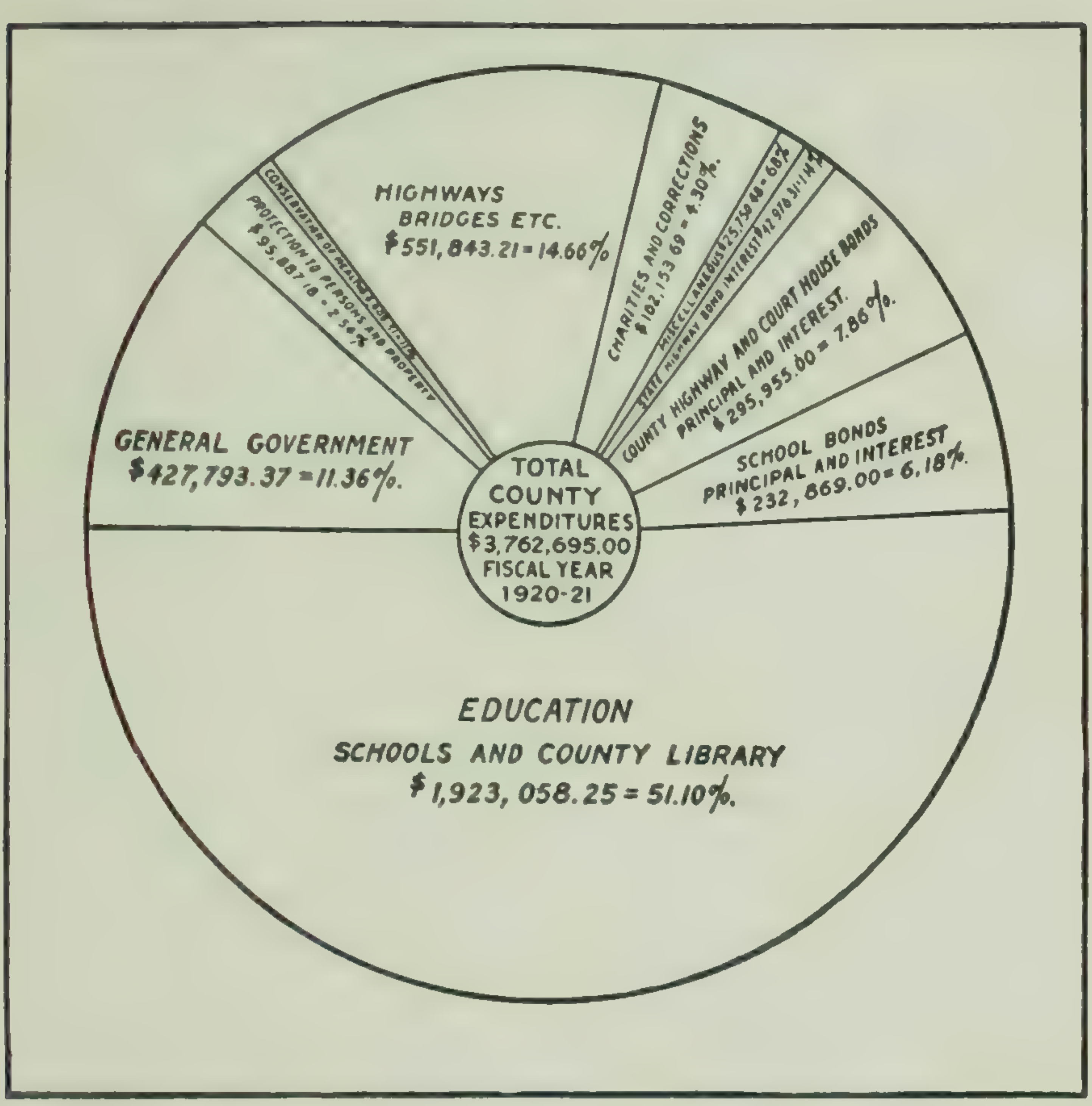


FIG. 52. DISTRIBUTION OF EXPENDITURES OF KERN COUNTY, CALIFORNIA, FOR THE FISCAL YEAR 1920–21

(From *Kern County Official Annual Statement.*)

Grouped sectors. Figure 53 illustrates the use of grouped sectors. Here the whole area of the circle represents the total enrollment of a state university. The students are classified into eight groups, according to the respective schools or departments in which they are enrolled. The sectors for the colleges, which include 74.6 per cent of the enrollment, radiate from a smaller arc which separates them from the rest of the chart. It should be noted that the percentage values of each of these sectors is based on total enrollment, not upon the college enrollment. Such explanations should be made in verbal descriptions accompanying circle charts.

The chart could be improved by transposing the sectors for Medicine and Engineering, so that the college group would appear in decreasing series. The sectors for Correspondence and High School should also be transposed so that the frequency order would be presented.

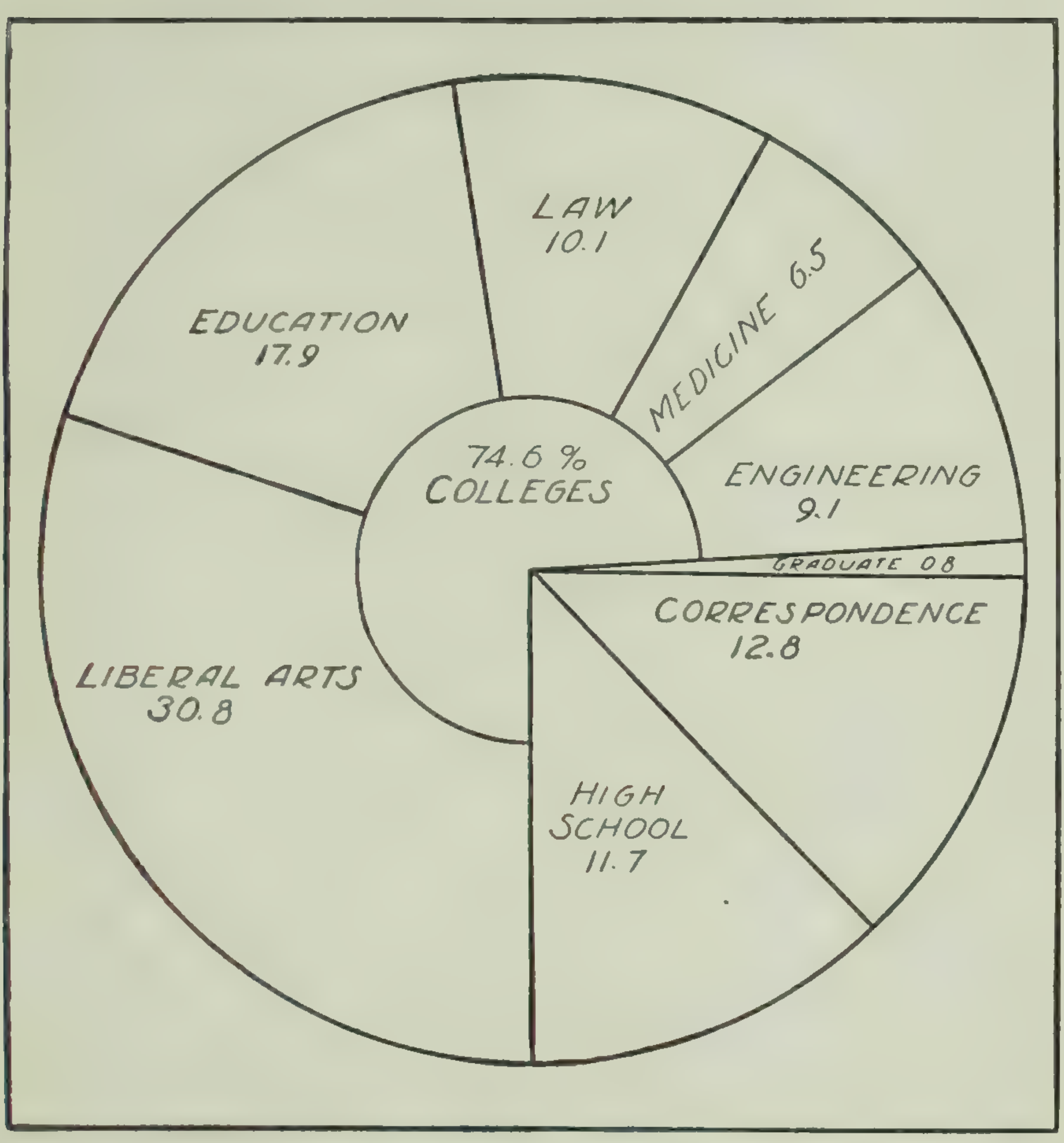


FIG. 53. DISTRIBUTION OF STUDENT REGISTRATION IN THE UNIVERSITY OF NORTH DAKOTA, 1914–15

(From United States Bureau of Education Bulletin no. 27. 1916.)

Comparative sectors in adjacent circles. In Figure 54 the first circle represents the total land area of a California county. The sectors show that 56.2 per cent (single hatched area) of the land is in farms, the remaining 43.8 per cent being devoted to other purposes. The second circle represents, by its whole area, the land in farms, which was shown as 56.2 per cent of the first circle. The sectors show that 62.7 per cent (single hatched area) of the farm land is improved. The reduction of comparative data to a percentage basis is sometimes useful in illustrating such facts. The circle method is clearer when the number of sectors is reduced to two, as in this case.

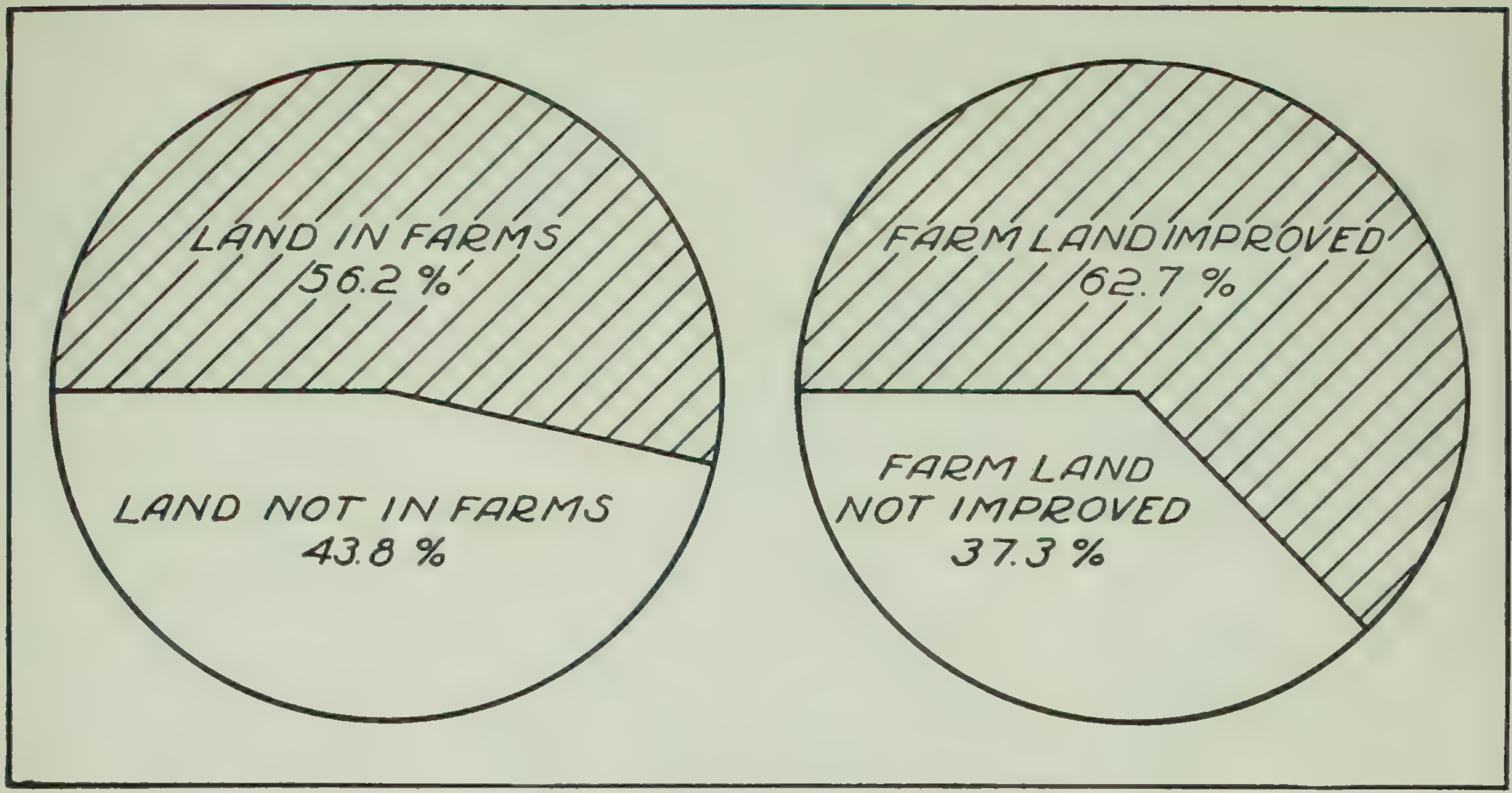


FIG. 54. FARM LAND DATA FOR SAN MATEO COUNTY, CALIFORNIA
(From United States Bureau of Education Bulletin no. 16. 1919.)

Multiple-sector comparisons. Figure 55 shows a series of seven circles, each representing, by a solid black sector, the attendance of a school. These are grouped around a large circle, which represents in a similar manner the attendance of all the schools. The small circles are arranged in order of the desirability of their records, the Garfield School, at the top, showing an attendance of 85.5 per cent, and the Franklin School, at the bottom, showing 64.1 per cent. The comparison between schools is not easily made, although this is facilitated by the use of numerical representation of the data. The outstanding value of such a chart lies in the fact that persons associated with each school may see how large a segment they will have to fill in order to have a more desirable record. The principal of the Franklin School should be convinced that his problem is one of serious magnitude.

It has been pointed out, in connection with some of the preceding charts, that shaded areas are often used to denote qualities, the least desirable being shown in solid black. If this rule were followed in constructing Figure 55, the attendance percentage would be shown in white and the absences in black, reversing the procedure used here. To do so in this case, however, would place too much emphasis on lack of attendance, the negative aspect of the problem. It is preferable to emphasize the desirable things whenever possible. The use of the black area for such a purpose is not incorrect, because it is really the only portion under consideration. The white area is merely a necessary result of numerical elimination.

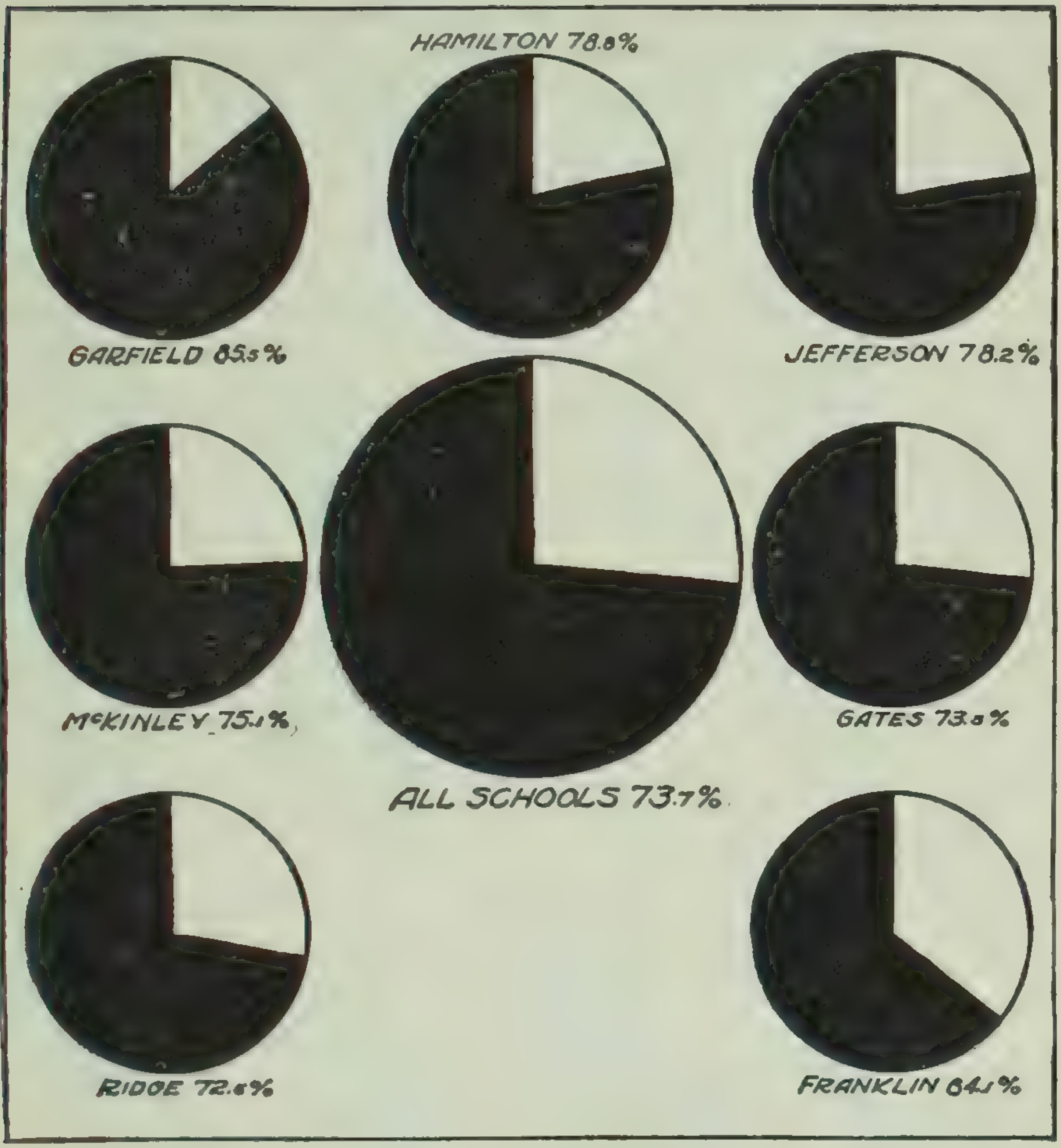


FIG. 55. PERCENTAGE OF PUPILS IN ELYRIA, OHIO, ATTENDING SCHOOL MORE THAN EIGHTY DAYS DURING THE FIRST HALF OF THE SCHOOL YEAR 1917–18

(Data from United States Bureau of Education Bulletin no. 15. 1918.)

Sectors in time-sequence. It is difficult to conceive a more effective way, from the standpoint of popular interest, of showing the changing value of the dollar than the method illustrated in Figure 56, used by the National Industrial Conference Board in their Report for 1922. The first circle is filled with solid black to represent the purchasing value of the dollar in 1914, with which, considered as having been one hundred cents, the values for subsequent periods are compared. The first six circles represent conditions by one year intervals, from July 1914 to July 1921. The second series represents intervals of one month from September 1921 to April 1922. Note that the decline was rapid until July 1920, when the lowest value (48.9 cents) was reached. The next year the value increased to 61.3 cents, from which there was but little significant change for the remainder of the period indicated.

The circles are constructed uniformly in size, and were spaced evenly by being centered at the intersections of four horizontal and four vertical penciled lines drawn with the aid of the T-square and triangle. The measurements are made in each circle from the top vertical radius. The dates and amounts are plainly indicated.

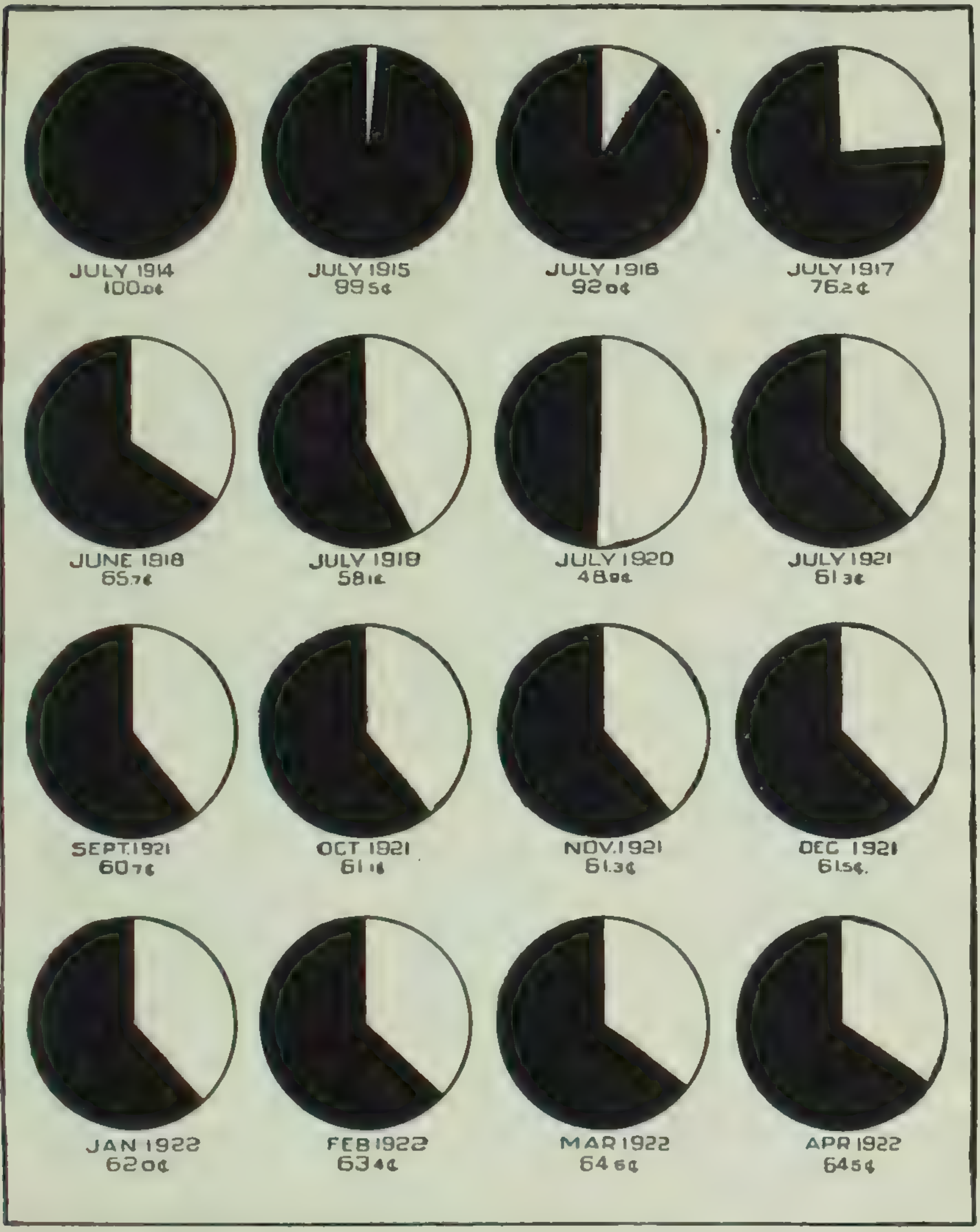


FIG. 56. PURCHASING VALUE OF THE DOLLAR, 1914 TO 1922
(Data from report of National Industrial Conference Board.)

Relative-position circular diagrams. The use of circles for diagrammatic representation of a group of associated facts is illustrated in Figure 57. Circles have a good advertising value because they attract the attention, especially when arranged in symmetrical design. The large circular area in the center is lettered to show the main subject under consideration, namely, instruction in printing. Around this is a series of eight smaller circles, representing the most important subjects which make up the technical printing course. These are enclosed in a large circle, outside of which are grouped seven circular areas representing subjects which are related to printing in a more general way. The space between the circles is inked in, and the solid area is extended to form a square which nearly encloses the entire group of circles. The slight projection of four of the outer circles is done for the design effect. Note that the sides of the square are slightly notched, in order to avoid a stereotyped appearance. The white circle is made by drawing two concentric circles and leaving empty the space between them.

By the use of such charts in advertising, the manufacturers of school equipment can help to inform the public concerning the practical aspects of educational work.

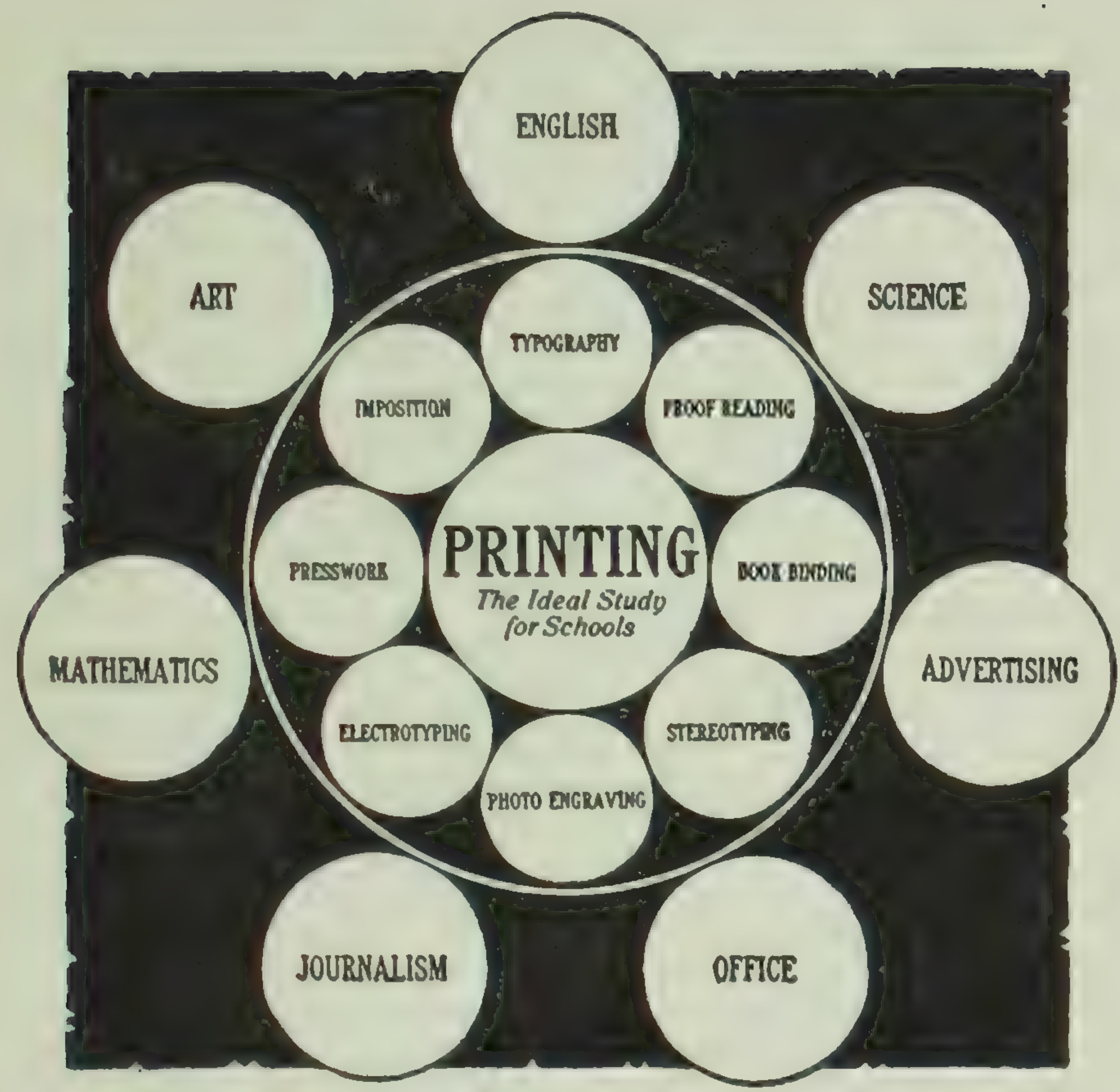


FIG. 57. THE RELATIONSHIP OF SCHOOL SUBJECTS WITH WHICH PRINTING INSTRUCTION IS CONCERNED

(From an advertisement in the *Journal of the National Education Association*, by Barnhart Bros. and Spindler.)

Radial plotting. This type of chart (Figure 58) is shown here because it is frequently used, and also to point out its limitations. Brinton, from whose book the chart was drawn, expresses the opinion that this method of charting should be "banished to the scrap heap." Although perhaps effective in attracting attention, it is so unsuited to satisfactory comparison that its bad features outweigh the good. A horizontal bar chart would serve much better to present the data shown here.

In radial plotting the scale is laid off on each of the radii, the center representing zero. The number of radii is determined by the number of items to be shown. The value of each item is indicated by a point laid off a corresponding distance from the center. These points are connected with a line, the course of which is intended to indicate the increasing or decreasing trend of the condition. The shading of the part enclosed by the curve is not essential, but brings out the area under consideration.

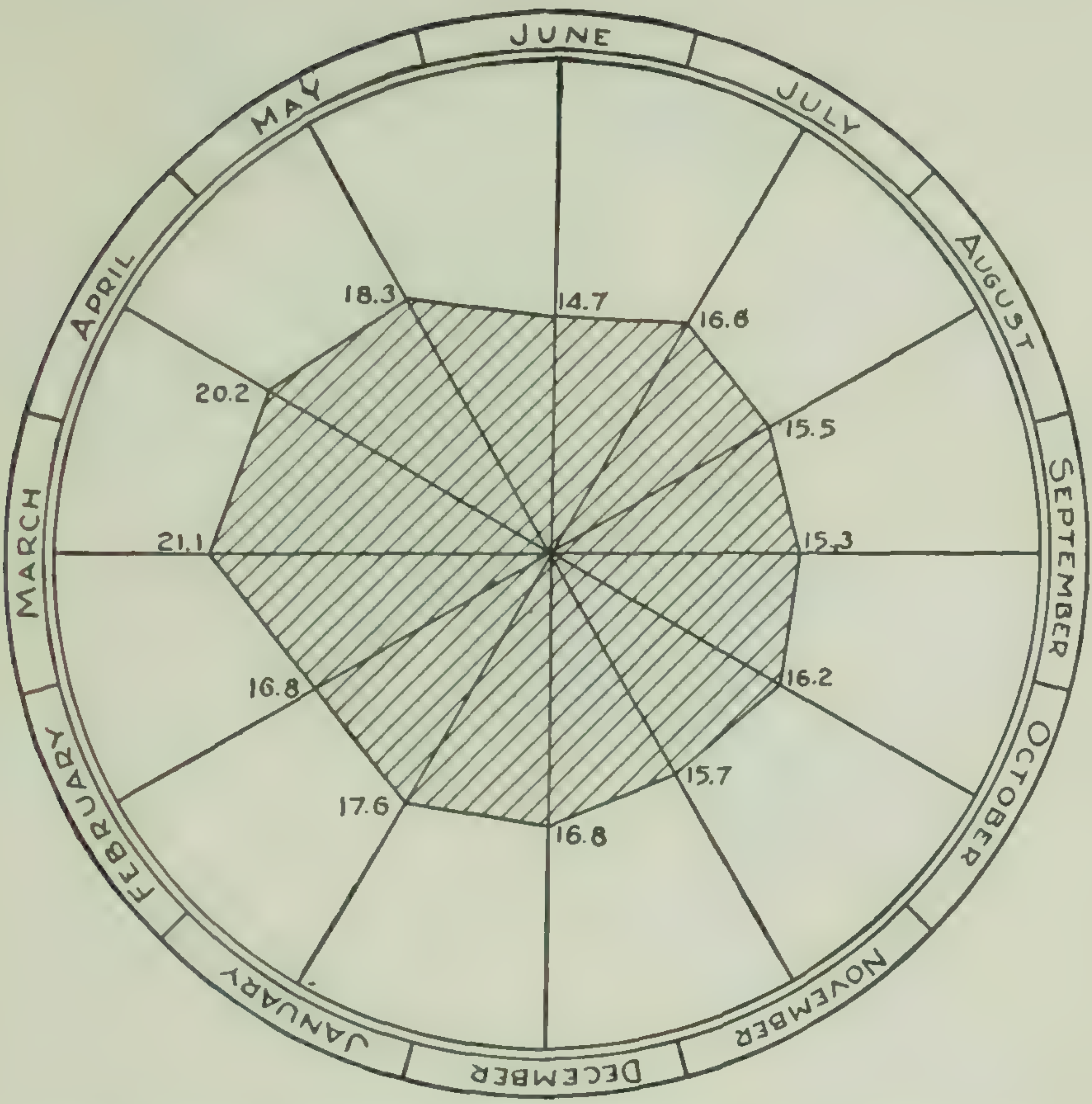


FIG. 58. DEATH-RATE FROM CONSUMPTION PER 1000 INHABITANTS FOR EACH MONTH OF THE YEAR IN THE UNITED STATES

(Data from *Graphic Methods for Presenting Facts*, by Willard C. Brinton.)

Radial segments. The "accident clock," shown in Figure 59, is based on the principle of radial plotting, but the values are indicated by the inking-in of the sectors in proportionate amounts. The circle is divided into twelve sectors, each of which represents an hour in the day. The hours are indicated at the end of the lines, and in Roman numerals to resemble the appearance of a clock. The inked-in portion indicates, for every hour in the day, the percentage of industrial accidents in the State of Illinois for a period of one year. The percentages are also shown numerically. Note that the number of accidents increases up to 12 A.M. and 5 P.M., which represent the time of the mid-day recess and the closing hour, respectively.

While the limitations of radial plotting referred to for Figure 58 also apply in general to this type of chart, an exception might well be made in this instance, because of the appropriateness of the clock idea.

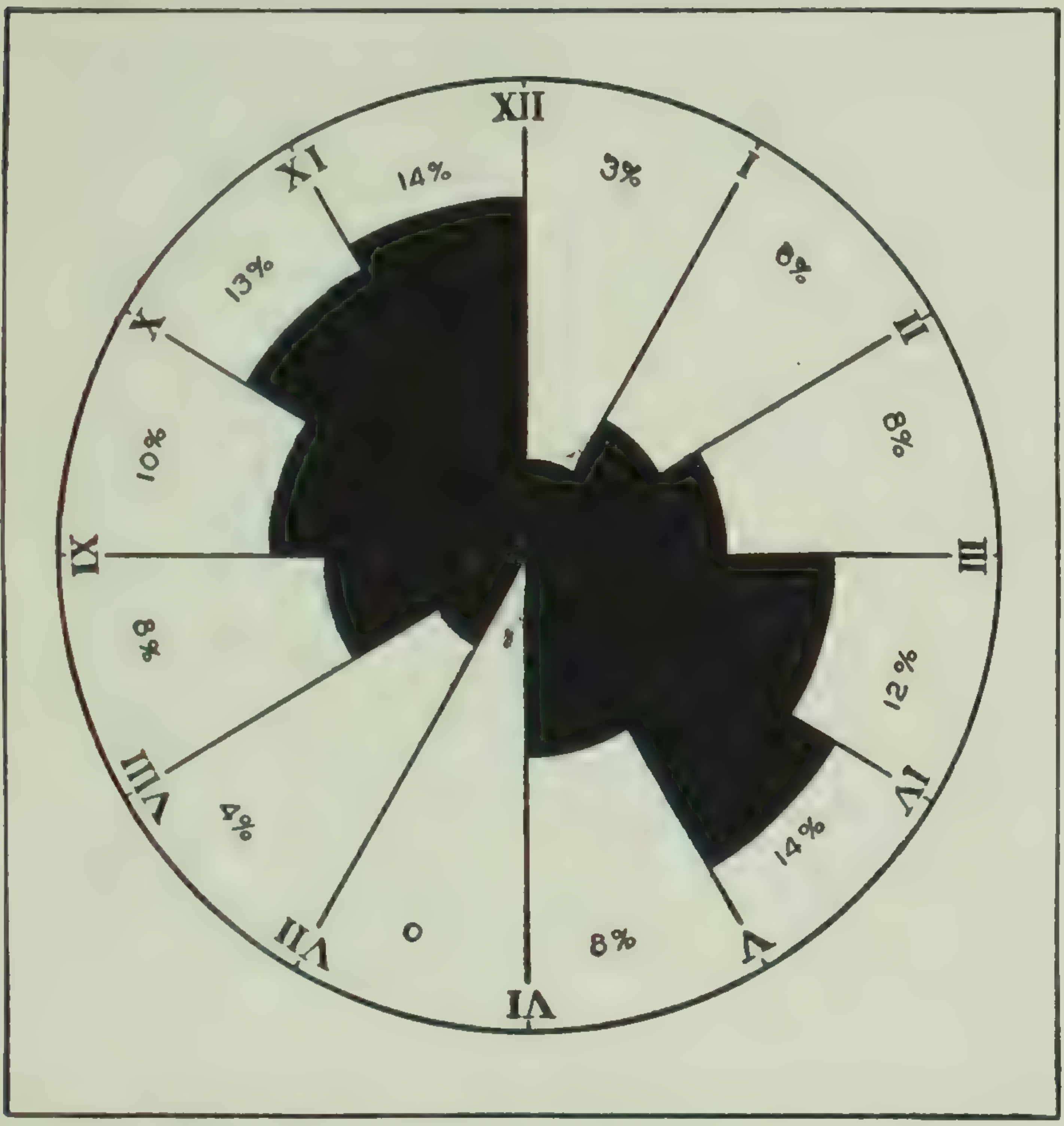


FIG. 59. THE "ACCIDENT CLOCK." BASED ON 1873 ACCIDENTS REPORTED FOR ONE YEAR IN ILLINOIS

(From *The Independent*, June, 1920.)

PROBLEMS FOR CHARTING

1. Construct a chart from geographical data similar to the one shown in Figure 49, but beside each circle place a vertical bar of the correct height for the data. Put the bars on the same base line, and show their heights by extending guide lines at intervals from a vertical scale at the left. Other comparisons which could be shown are the areas of the continents, the areas of the Great Lakes, the leading imports, and the principal products of any State.
2. Draw a chart on the plan of Figure 50, the data being the population of the six largest cities in the World.
3. Obtain data relative to how your city spends its dollar, and construct a chart on the plan of Figure 51.
4. Redraw Figure 53 according to the suggested corrections.
5. Draw a circle representing your city, or a school with which you are familiar, and show the attendance record as in Figure 55.
6. If you can obtain the data, draw a chart bringing Figure 56 to date.
7. Using for subject-matter some other course of instruction, make a diagrammatic chart similar to Figure 57, showing the interrelationship of subjects.
8. Reconstruct Figure 58 as a vertical bar diagram.
9. Record the temperature for each hour in a day, and show the data in a clock chart, following the plan of Figure 59.

CHAPTER VI

CURVES

(EXPLAINING FIGURES 60 TO 72, INCLUSIVE)

General definition. A curve is a line connecting a series of points whose relative positions indicate comparative values. It is not always a *curved* line in the ordinary meaning of the term, although it may take such a direction as to appear curved. Statistical curves are usually made up of a series of short straight lines, each of which connects two points on the chart. The chief purpose of the curve is to show *trends* of facts; as illustrated in the following chart showing the upward trend of college libraries in number of volumes. The method is also used to show *variability*, especially in cases in which fluctuations from a given standard are deemed to be significant.

The curve is probably the most useful and widely used form of graphic presentation. When properly constructed, it lends itself to a high degree of accuracy. It is also less spectacular than some of the other methods, and for that reason is preferred by many scientific workers whose reports are mainly for technical use and discussion, and for whom popular appeal is of minor importance.

Each point on a curve chart represents a relative position on two scales, intervals of which are shown at the left and bottom, usually beginning with a heavy zero line. The base line is a very important feature, and without it the chart may be misleading. Figure 3 is an example of this kind. It should have been drawn with a base line, and a separation effected according to the method illustrated in Figures 45 and 68.

Brinton (p. 71) expresses the following opinion concerning the importance of curve charting:

> An understanding of how to plot curves and of how to read them should be part of the equipment of every business man, just as it is of every engineer, physician, biologist and statistician. The general scheme of curve plotting is so simple that instruction in it should be given as part of the work in elementary arithmetic in all public schools. Children over ten years of age can do plotting and can understand simple curves.

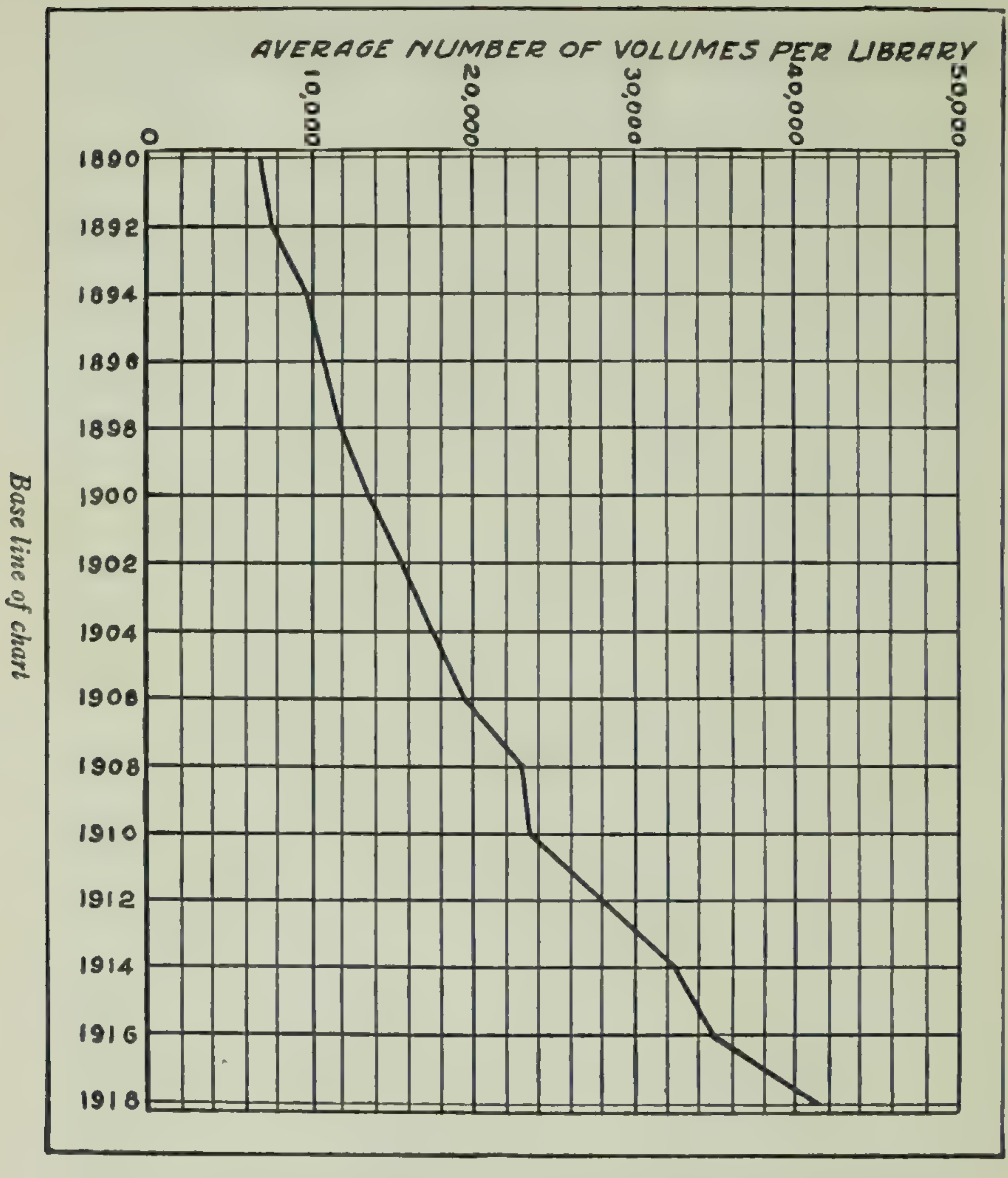


FIG. 60. GROWTH OF UNIVERSITY AND COLLEGE LIBRARIES, 1890–1918
(Data from United States Bureau of Education Bulletin no. 34. 1920.)

Cumulative curves. Figure 60 illustrates the use of the curve for showing accumulation, or growth. The subject in this case is the number of books in university and college libraries, from 1890 to 1918. The horizontal scale is divided into intervals of two years, reading from left to right, each biennium being represented by a line drawn perpendicular to the base. The vertical scale, representing the number of volumes, reads from zero to 50,000. The guide lines run horizontally through the chart in intervals of 2000 volumes. Each fifth guide line is drawn heavier, to represent the "round" intervals 10,000, 20,000, etc., up to 50,000, the first round number beyond the maximum value of the data. On each of the vertical year-lines a point is plotted, the height of which, according to the scale, indicates the number of volumes for that year. Thus for 1890 the number is 7000; for 1892 it is 7800; while the maximum shown, for 1918, is 41,500. The points are connected by a heavy line, which shows the *trend* to be consistently upward. If the number decreased year by year, or for any single year, the fact would be indicated by a downward direction of the curve.

Although the points are actually connected by straight lines, the increase in this case is so gradual that a continuous line effect is obtained. Note for example the even upward curve from 1894 to 1906; and from 1910 to 1914. In 1910 the growth was suddenly retarded, so that the direction of the line between 1908 and 1910 is nearly horizontal. Then comes a period of acceleration which is maintained until 1914, when the rate is slightly retarded until 1916, when a still greater acceleration begins. It should be remembered that each two-year period represents the accumulation of all the previous years, to which the number of new books is added. The figures are based on the *average number of volumes* per library for a large number of universities and colleges.

Inasmuch as time has no beginning, year scales do not have base lines. In this case, additional thin vertical lines are drawn just before the line for 1890, and just after the line for 1918.

Frequency-distribution curves. Figure 61 shows the frequency distribution of mental-age ratings of a group of industrial school pupils. The mental ages, indicated at the base, range from six years to the adult level. The vertical scale at the left, representing the number of cases, ranges from zero to 120, divided into intervals of twenty cases, shown by the guide lines. The frequency for each age-group is indicated by a point on the vertical line, and each two adjacent points are connected with a heavy line. The combined straight lines make up the curve, which is the most prominent feature of the chart. In drawing charts of this type care should always be taken to make the guide lines light, so that the curve can be read easily. It frequently happens that the curve closely follows one of the perpendicular lines for a short distance, in which case the contrast is especially important.

In the distribution shown here the trend of the curve is not uniform, because the deviations are large. The high frequency for the eleven-year age level brings the line to a sharp angle, which is not uncommon to frequency distributions, and which in statistical work is called the "peak" or the *mode.* It is an especially significant group, and is one of the measures of central tendency.

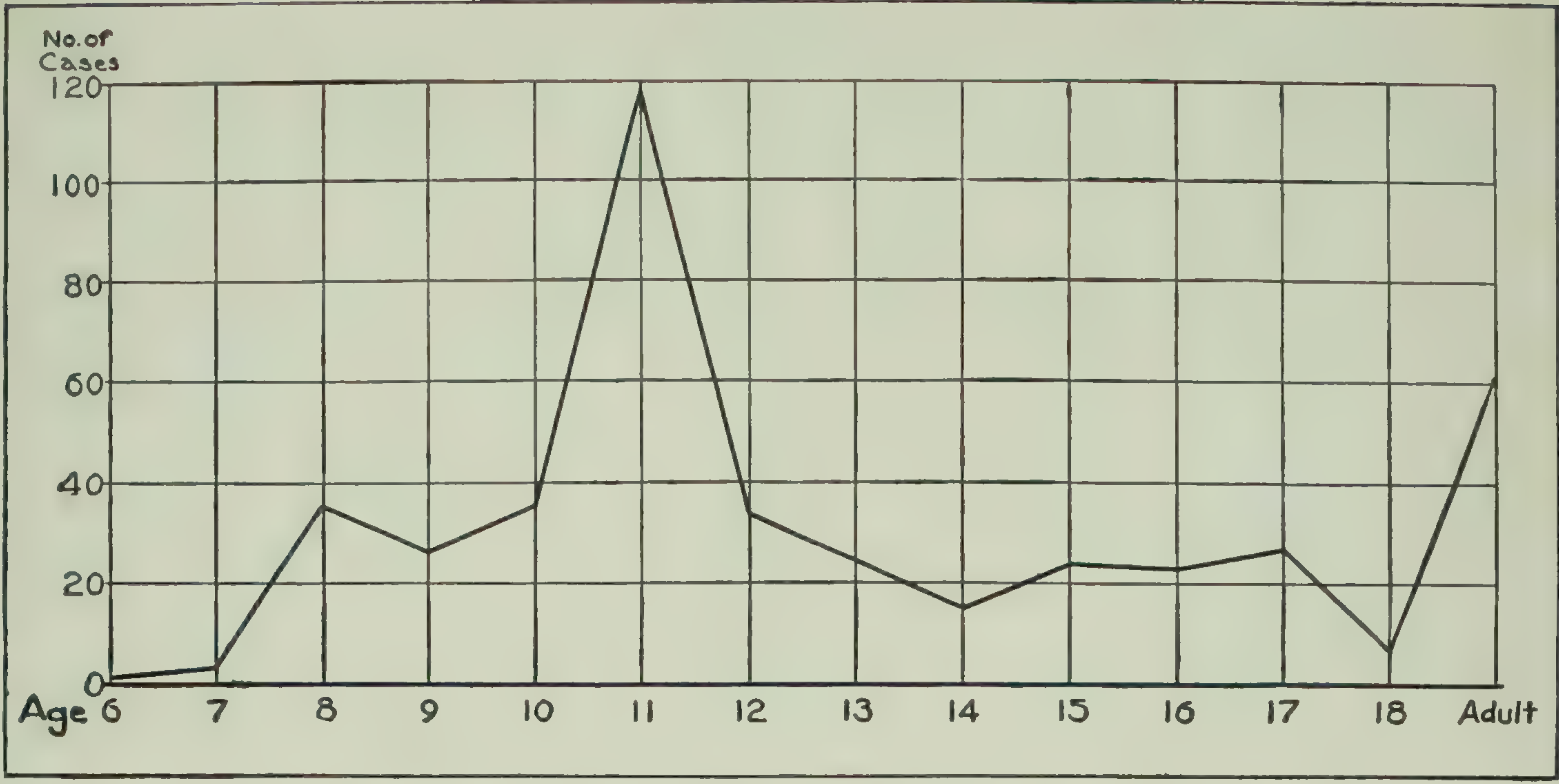


FIG. 61. MENTAL-AGE RATINGS AT THE WISCONSIN INDUSTRIAL SCHOOL, AT WAUKESHA
(From data reported in survey by V. V. Anderson.)

Profile curves. Figure 62 represents the ratings of a single child in a mental test, which consists of twelve parts. The maximum score for each part is ten points. By measuring the scores on the vertical scale, and using a vertical line to represent each of the tests, we can plot points for a curve which will give the so-called "profile" effect. This is not a cumulative or frequency chart, but a series of individual measures. The test numbers are in Roman numerals, to make it more apparent that they are merely names of tests, and not values. The large dots and extra heavy connecting lines add to the prominence of the curve, but are not essential.

The data from which the chart was drawn are as follows:

Test No.	Score
I	2
II	6
III	7
IV	7
V	6
VI	8
VII	9
VIII	10
IX	10
X	1
XI	6
XII	3

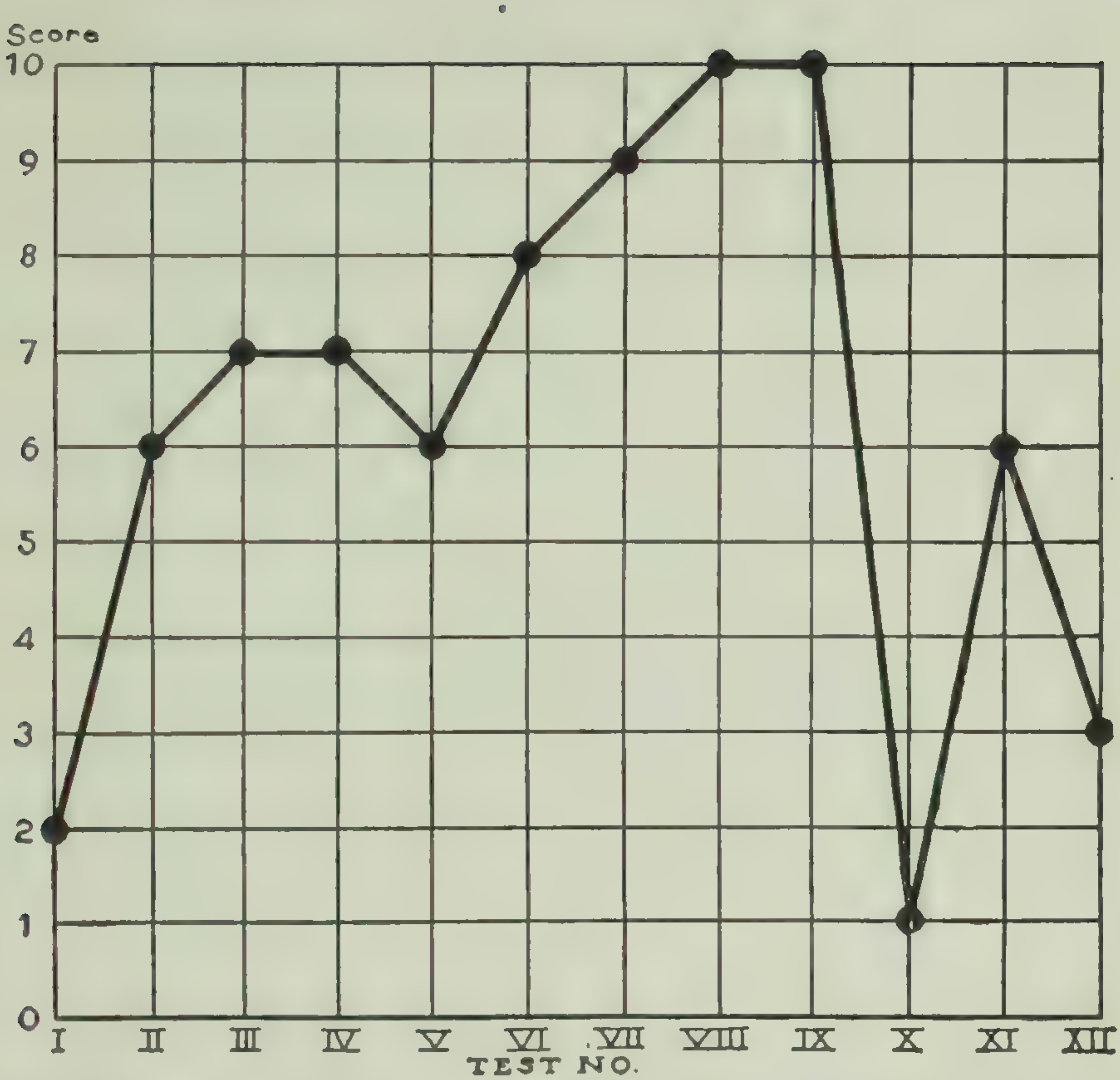


FIG. 62. "PROFILE" RATING OF A WHITTIER STATE SCHOOL BOY, ON THE DOWNEY WILL-TEMPERAMENT TEST

(After Edythe K. Bryant, in *Journal of Delinquency*, January, 1921.)

Variability curves. Figure 63 graphically represents the results of a psychological experiment in the effect of drugs upon certain psycho-motor processes. The points on the horizontal scale represent first, the normal status of the individual, or his condition at the beginning of the test; then fifteen minutes later; and intervals of ten minutes thereafter. The vertical scale is the measure of the number of errors made in the performance of the test. The zero line is placed at the top, in this instance, because the quality of the performance bears an inverse relationship to the number of errors. The result of each test, recorded in errors, is indicated by a point. The connections between the points make up a curve, representing the changes in efficiency as the drugs took effect, and as the effects wore off. The number of errors at the start was 82. At the end of fifteen minutes it was reduced to 53; then, after ten minutes, to 52; then to 26, which indicates the highest level of efficiency reached. Thereafter the results show marked variability, and at the end of 105 minutes the normal condition was restored. The limits of normal variability are 60 and 90, from which horizontal dot-lines are drawn across the chart. It is only beyond these limits that the deviations are significant.

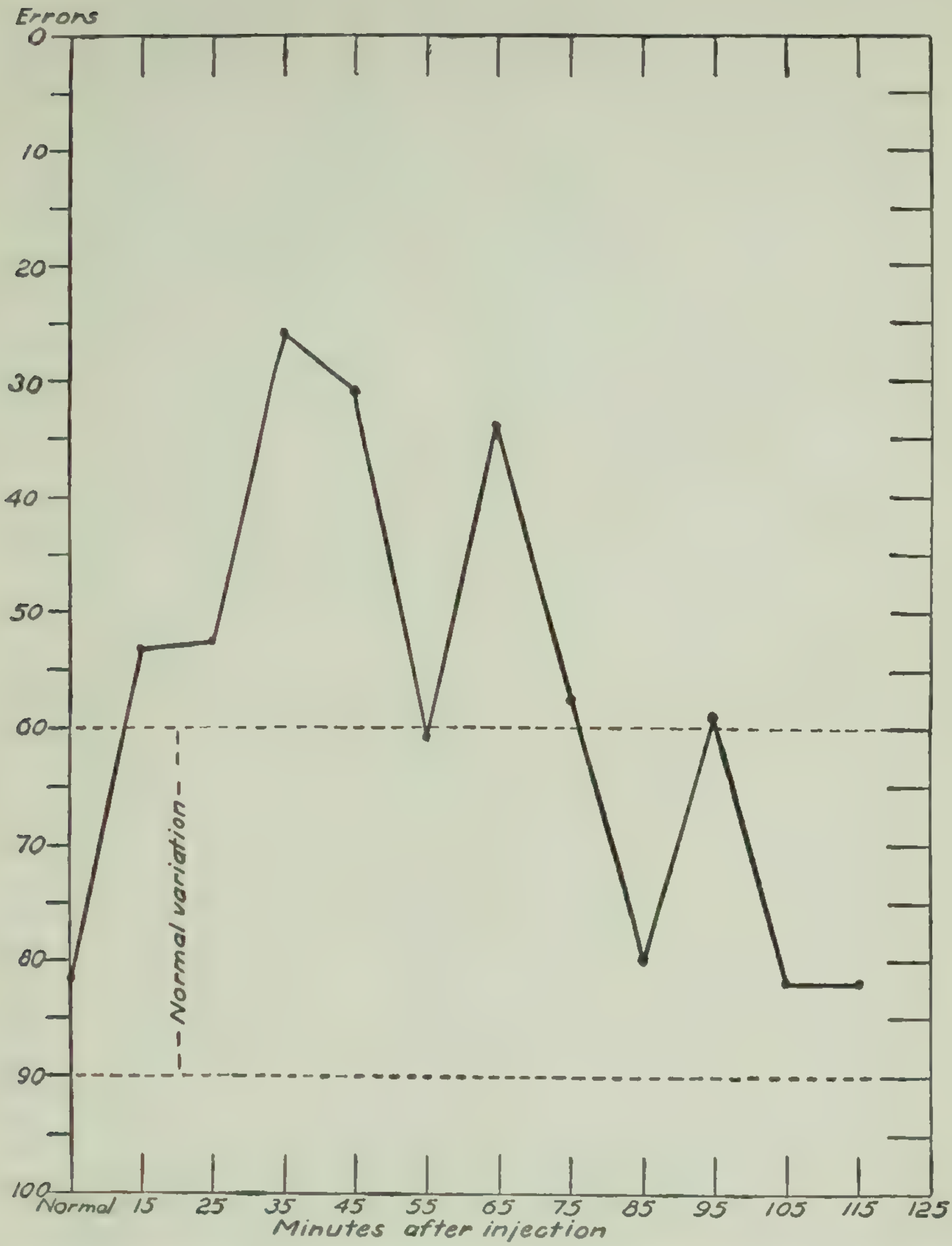


FIG. 63. EFFECT OF A HYPODERMIC INJECTION ON EFFICIENCY IN A PSYCHO-MOTOR TEST

(After MacDougall and Smith, in *The Effects of Alcohol and Some Other Drugs during Normal and Fatigued Conditions.* London, 1920.)

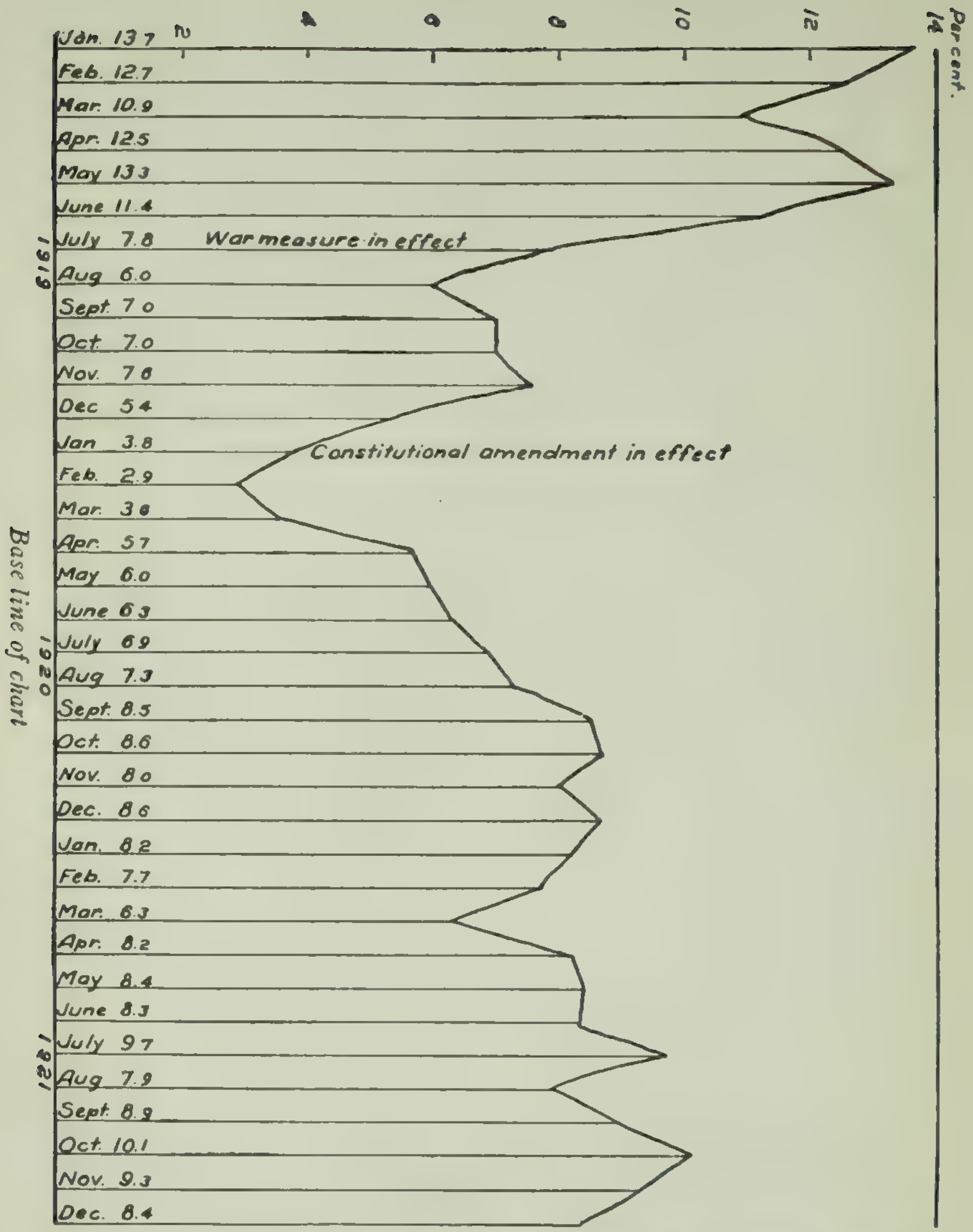


FIG. 64. DRUNKENNESS AS A CAUSE OF FAMILY DESERTION AND NON-SUPPORT, IN TERMS OF PERCENTAGE OF TOTAL FACTORS

(After S. H. Patterson, in *Journal of Delinquency*, September, 1922.)

A "profile-effect" variability curve. Another form of variability curve is shown in Figure 64. The subject here is the fluctuation in family-desertion and non-support attributed to drunkenness. The purpose of the investigation on which the chart is based was to determine whether the conditions in this respect are getting better or worse. The range of time covered is three years, from January, 1919, to December, 1921. Each of these months is represented by a vertical line, on which the percentage is indicated by a point, at which the line is discontinued. This gives a "profile" effect, and was designed to aid in showing the trend. The vertical scale is shown at the left, in intervals of 2 per cent. No limits of normal variability are shown, as in the previous chart, so it is difficult to interpret the significance of the deviations. There are probably no available data on which such limits could be based. However, it is plain that there was a marked decline for 1919; that the lowest point was reached in February, 1920; and that thereafter there was a rapid increase, with minor deviations during 1921. Since October, 1920, there is the beginning of another rapid decline.

Comparative-frequency curves. Figure 65 shows the frequency-distribution of infant mortality by months, for two types of diseases. The months are indicated by twelve vertical lines, with appropriate designations at the bottom. The vertical scale shows the frequency. The two groups are clearly distinguished by the use of a continuous line for one, and a dot line for the other. The choice of lines in this instance is not based on relative importance or value, but merely on the necessity for identification. Note that each type of disease has its peak, or mode, according to the time of year in which it is most often fatal.

The principle of comparative frequency curves can be carried out with any number of groups, provided each is clearly designated by a separate type of line, and the direction of each can be clearly shown.

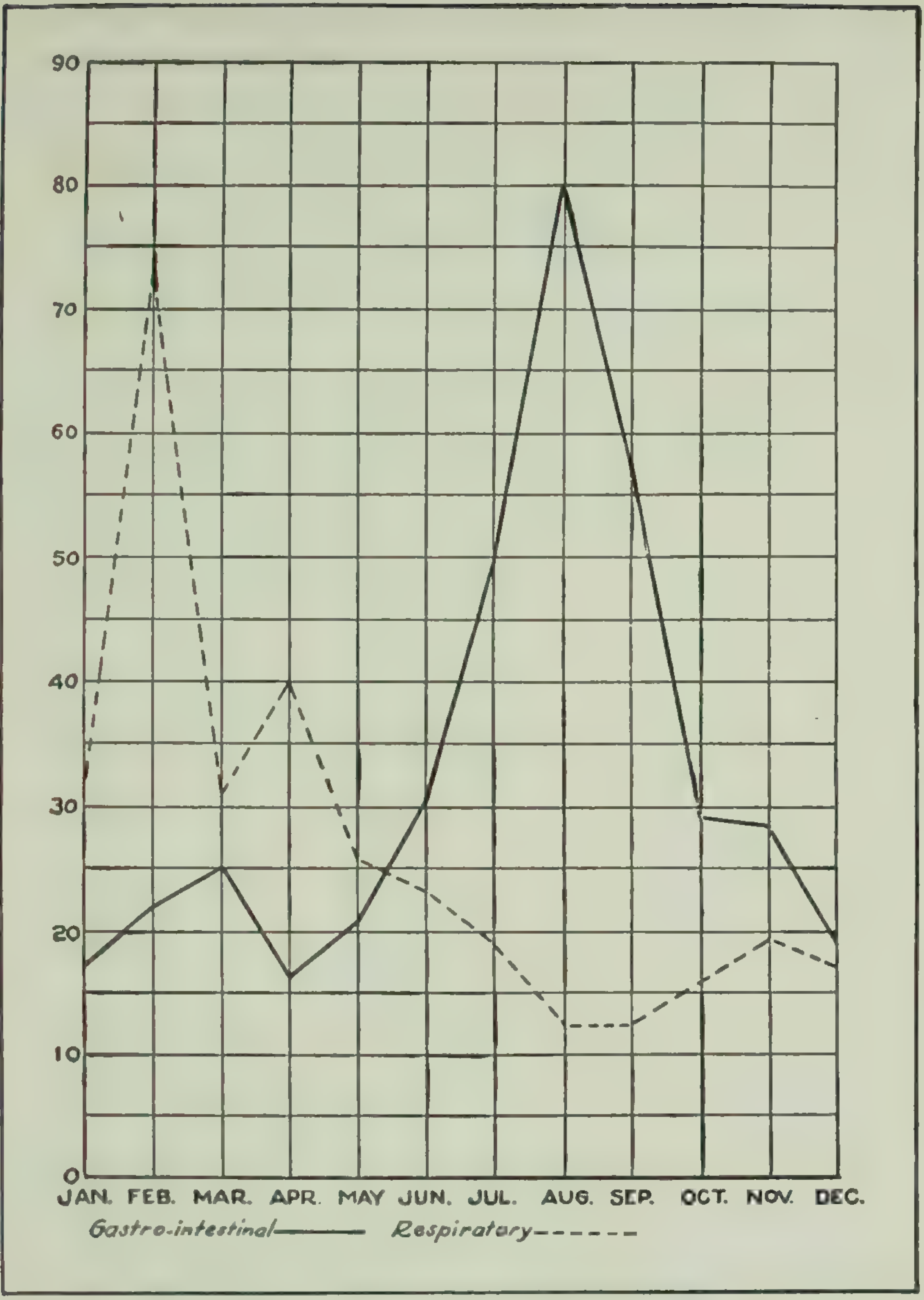


FIG. 65. NUMBER OF DEATHS FROM GASTRO-INTESTINAL AND RESPIRATORY DISEASES IN PITTSBURGH FOR 1920

(Data from United States Children's Bureau, Publication no. 86. 1921.)

Another type of comparative-frequency curve. Another comparative-frequency curve chart is shown in Figure 66. The base measure is a scale of years, and the vertical scale the measure of frequency. The comparison is between the professional training of elementary-school teachers of Elyria, Ohio, and the training of teachers in twenty-four Arizona cities. The curve for Elyria is a continuous line, because of its relative importance. The Arizona cities, which are used merely for the purpose of comparison, and not as a principal feature, are represented by a dot line. The Elyria line is also heavier. Note that it is continued along the base line for the last three intervals. To show this continuance the frequency line is added to the thickness of base line, instead of being discontinued at the 7–8 year interval, which might lead to the inference that there were no data for the remaining intervals.

No key or legend is needed for this chart, because the subject of each frequency curve is plainly indicated on it.

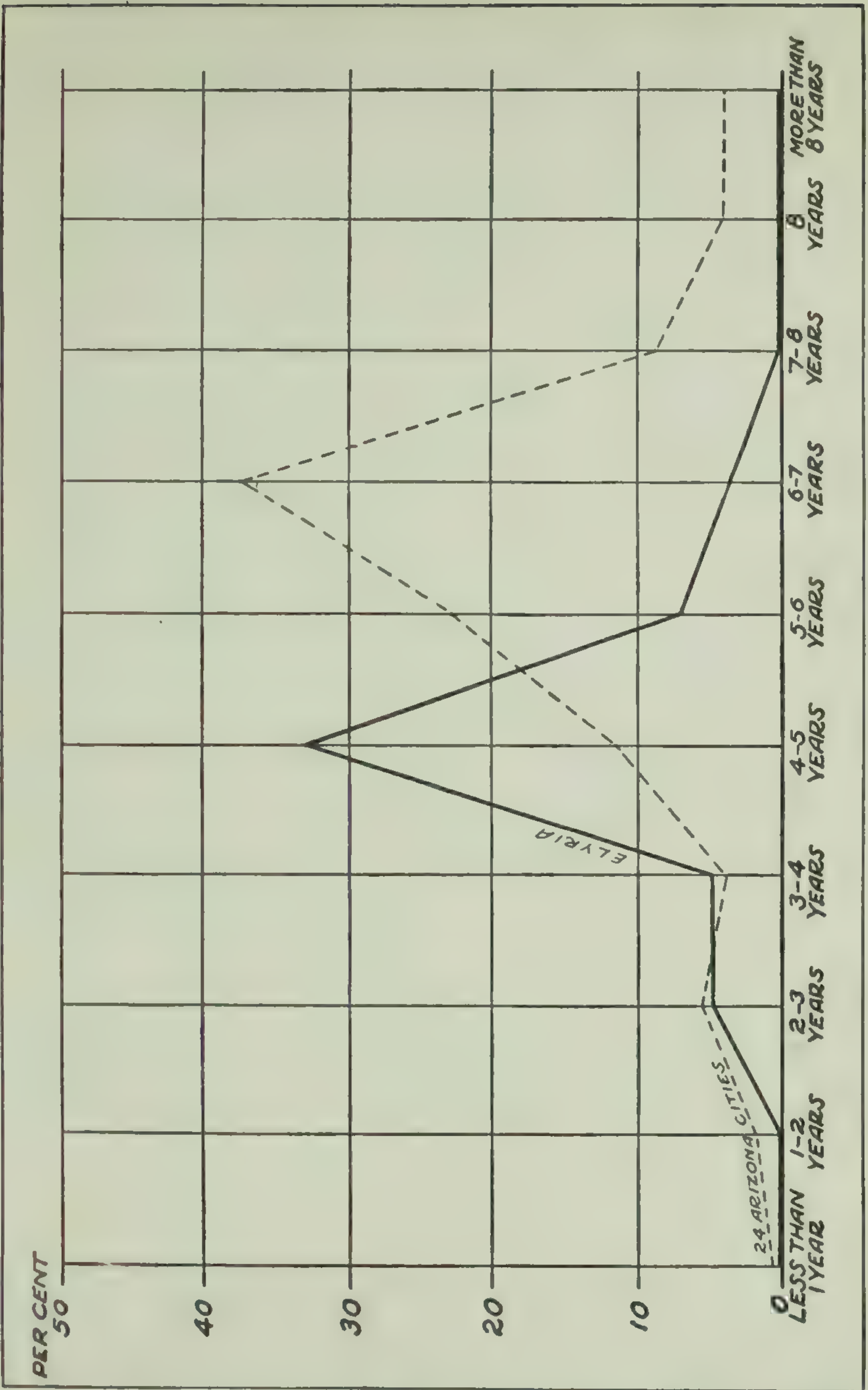


FIG. 66. POST HIGH-SCHOOL TRAINING OF ELEMENTARY-SCHOOL TEACHERS IN ELYRIA, OHIO, IN COMPARISON WITH TEACHERS IN ARIZONA

(From United States Bureau of Education Bulletin no. 15. 1918.)

Percentage curves. In Figure 67 two variables are compared, as in the two previous charts. In this case it is important to show, not only how the two frequency curves compare with each other, but also what relation each frequency interval bears to the total percentage. In 1854, for example, the men teachers in Ohio comprised 53 per cent of the high-school teaching force, and 54 per cent of the elementary-school force. In order that these may be seen in relation to the whole group of teachers, the vertical scale is drawn to 100 per cent. It is unnecessary, however, to show the upper 25 per cent of the chart, inasmuch as it is not used. The scale is represented as being broken apart, and the unused portion eliminated. This method has been referred to in connection with Figure 45. If the scale should appear to be limited to the space actually used, it would give the impression that the number of men teachers in high school nearly reached the maximum; whereas the percentage values show that such was not the case.

The interpretation of this chart is both interesting and significant. In 1854 the proportion of men teachers in the elementary schools was slightly above the proportion for high schools. From that year there was a rapid decline for the elementary schools, while the proportion for the high schools was on the increase. The high schools reached a low point in 1874, after which the frequency climbs to 68 per cent, at which level it remained for several years. This continuance of a given frequency for a number of intervals is called a "plateau," which is suggested by its appearance. From this level a rapid decline began, after 1902, which is still in effect. The elementary schools reached a low point in 1866, from which there was a slight increase for a few years, followed by a steady decline. In 1921, the last year shown on the chart, the proportion of men teachers in the elementary schools had decreased to 12 per cent.

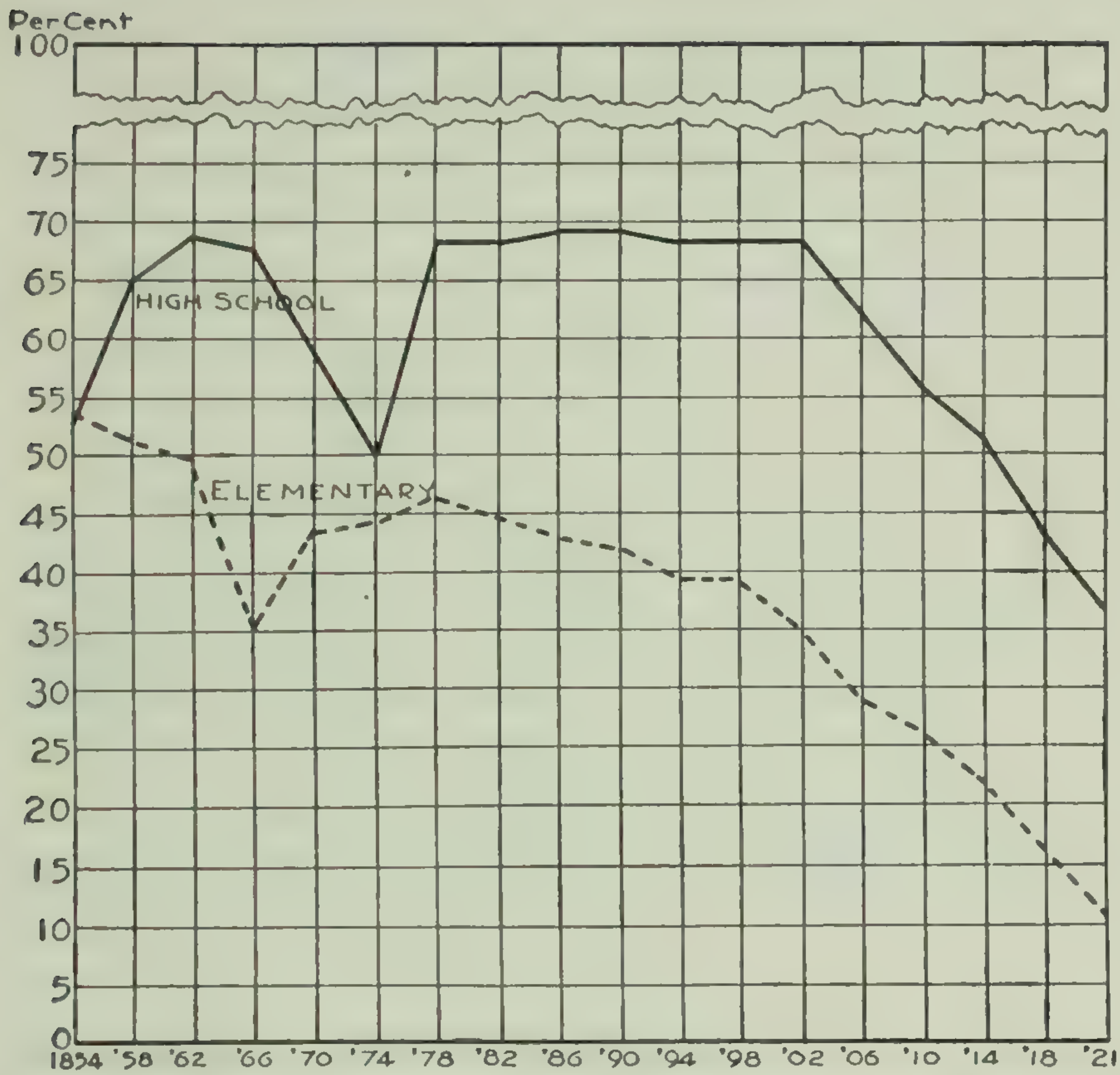


FIG. 67. PERCENTAGE OF MEN TEACHERS IN THE PUBLIC SCHOOLS OF OHIO, 1854 to 1921

(From table by P. R. Stevenson, in Ohio *Educational Research Bulletin*, June 13, 1923.)

Relative-position curves. Figure 68 represents the standing of an elementary school in a test comprising two elements — *rate* and *quality*. The scores for rate are measured on the vertical scale, those for quality on the horizontal scale. The norms, or standards, for each grade are shown by a small circle, so placed that it represents the correct measure on both scales. The norms shown on this chart are as follows:

Grade	Quality	Rate
3	40	40
4	44	56
5	48	64
6	52	70
7	56	76
8	60	78

Connecting lines between these circles make up the curve of norms. Positions to the right and left of this curve represent *better* and *poorer* scores, respectively, in *quality;* positions above and below it represent better and poorer scores, respectively, in *rate.* The Lincoln School, in comparison with the norms, makes an irregular showing. It is consistently superior in quality, but, for most grades, below the standards in rate.

Note that the chart is broken and separated near each of the base lines, in order that the zero lines may be shown without using unnecessary space.

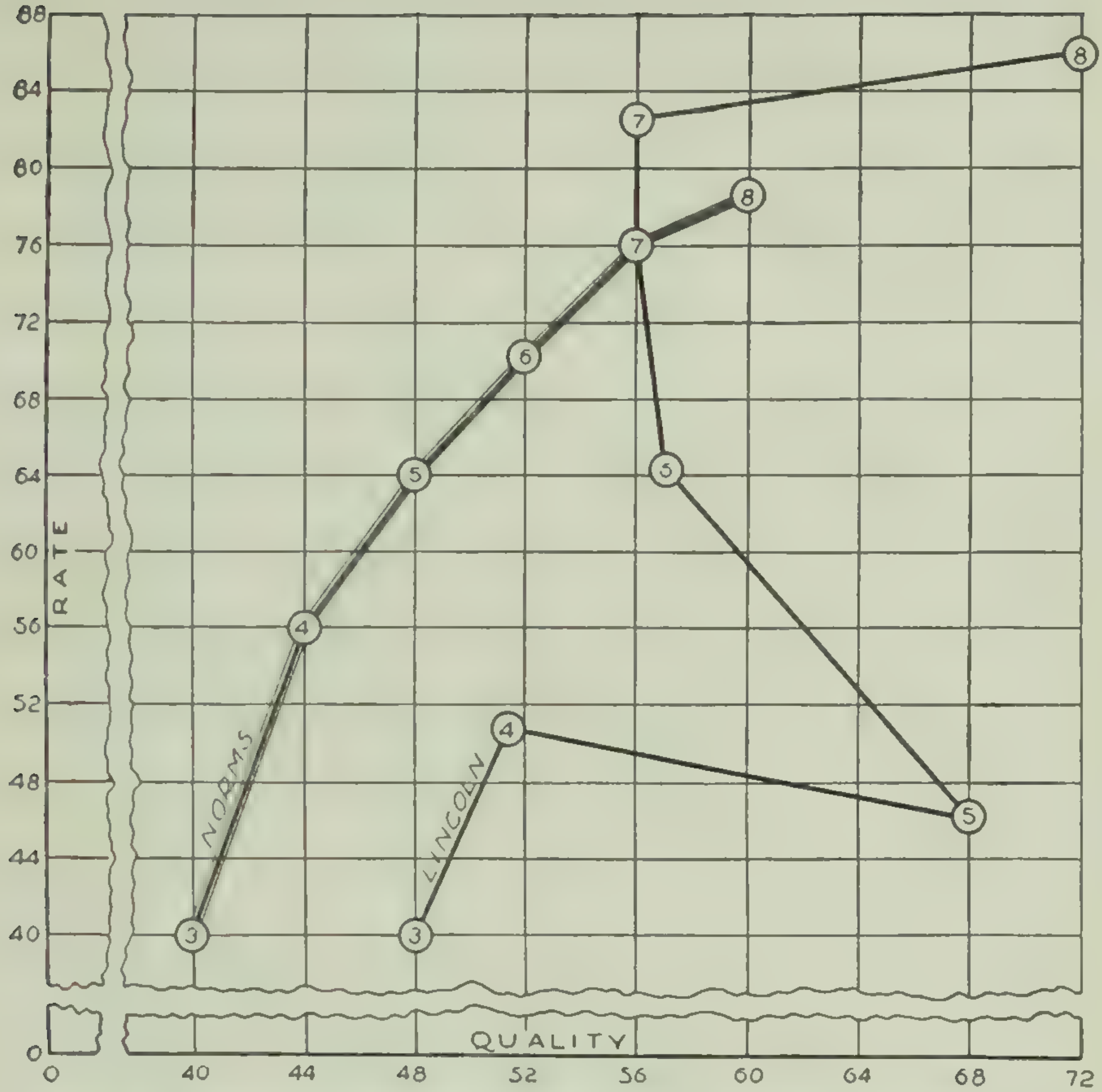


FIG. 68. RESULTS OF THE APPLICATION OF A STANDARD TEST IN A CITY SCHOOL, SHOWING RATE AND QUALITY IN COMPARISON WITH NORMS FOR ELEMENTARY-SCHOOL GRADES

(Illustrating the "broken" chart.)

A complex or composite chart. Figure 69 is a complex chart, made up of a number of curves each deviating from a different base line. The purpose is to show the elements concerned in judging reading ability, and how these elements may vary among children, or in the reading achievement of a single child.

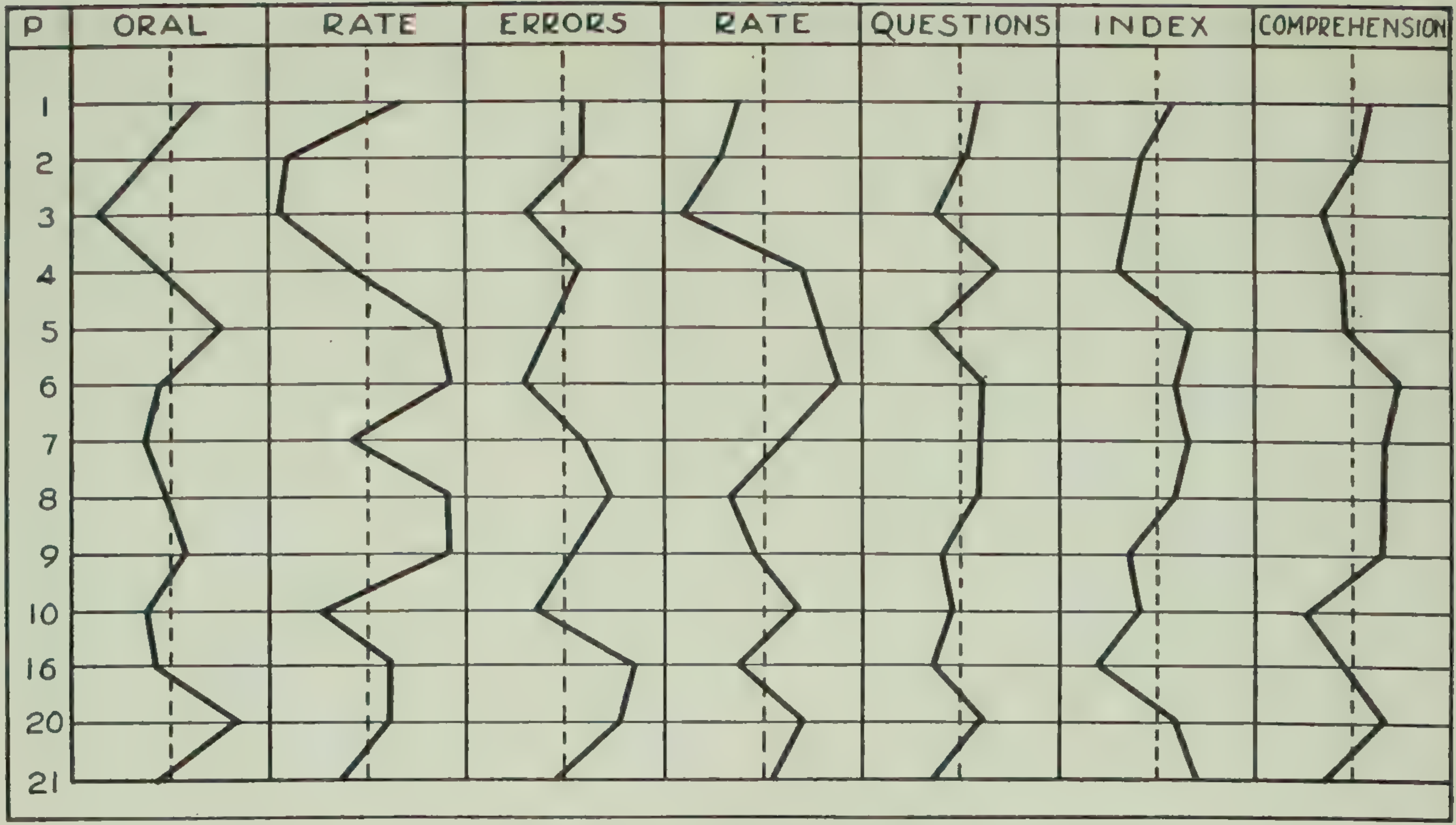


Fig. 69. Ratings on Gray's Diagnostic Chart for Reading Ability
(From *Deficiencies in Reading Ability*, by W. S. Gray.)

Shaded-area curves. It is frequently desirable to shade in the area bounded by a curve and the base line, or between two curves. Both of these methods are illustrated in Figure 70. The subject is the number of teachers employed in the public schools of Detroit for a period of eleven years, with special reference to the relative proportion of men and women teachers. The total number is shown by the upper curve, ranging from 1600 to 4250. The number of women teachers ranges from 1490 to 3800. The number of men employed is shown by the difference between the two curves. By double hatching the lower portion, and single hatching the space between the curves, the idea of volume is emphasized.

The vertical scale, at the left, is spaced by intervals of 500, alternate guide lines being drawn heavier than the intermediate lines and preceded by indicating numerals.

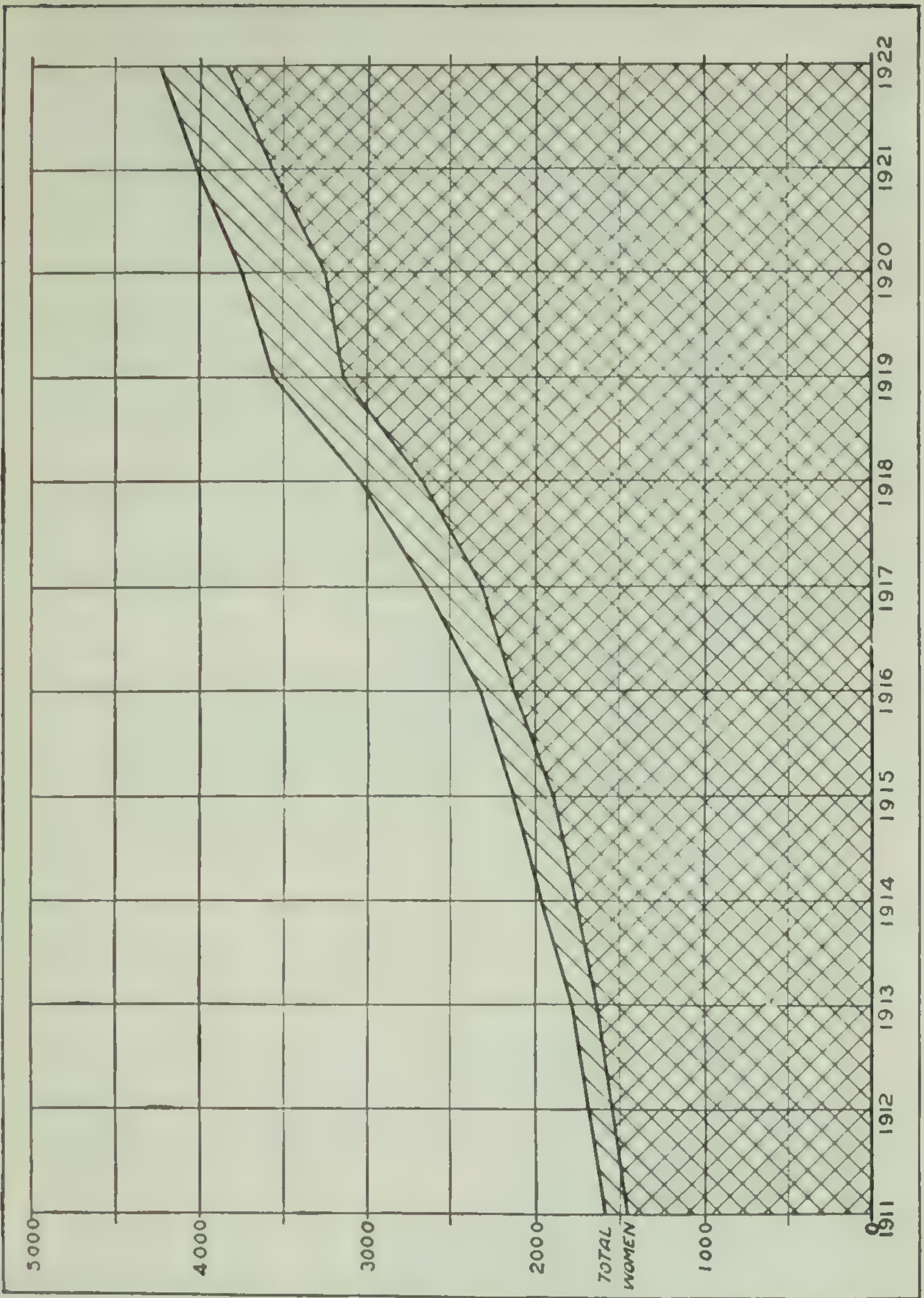


FIG. 70. NUMBER OF TEACHERS EMPLOYED IN THE DETROIT PUBLIC SCHOOLS AT THE END OF EACH SCHOOL YEAR, 1911 TO 1922

(Data from 1922 *Report of Detroit Public Schools*.)

A striking illustration of the use of shaded areas in curve representation is given in Figure 71. Here the curve represents the fluctuation in cost-of-living prices from 1810 to 1920. The area below the curve is filled in with solid black, so that the effect resembles a silhouetted mountain range, with a few prominent peaks. These peaks indicate periods in which living costs were abnormally high, and each occurs in connection with a disastrous war. A marked depression is shown between 1890 and 1900.

In order that the guide lines may be shown through the black area, they are made white. This is accomplished by drawing two parallel lines separated by the required space, which is left empty when the remainder is inked in. As originally published, the vertical lines were shown in the same manner.

To illustrate how a time chart may be prepared for future additions, the horizontal scale is continued, without data, to 1930. The extension could, of course, be carried out to any desired point.

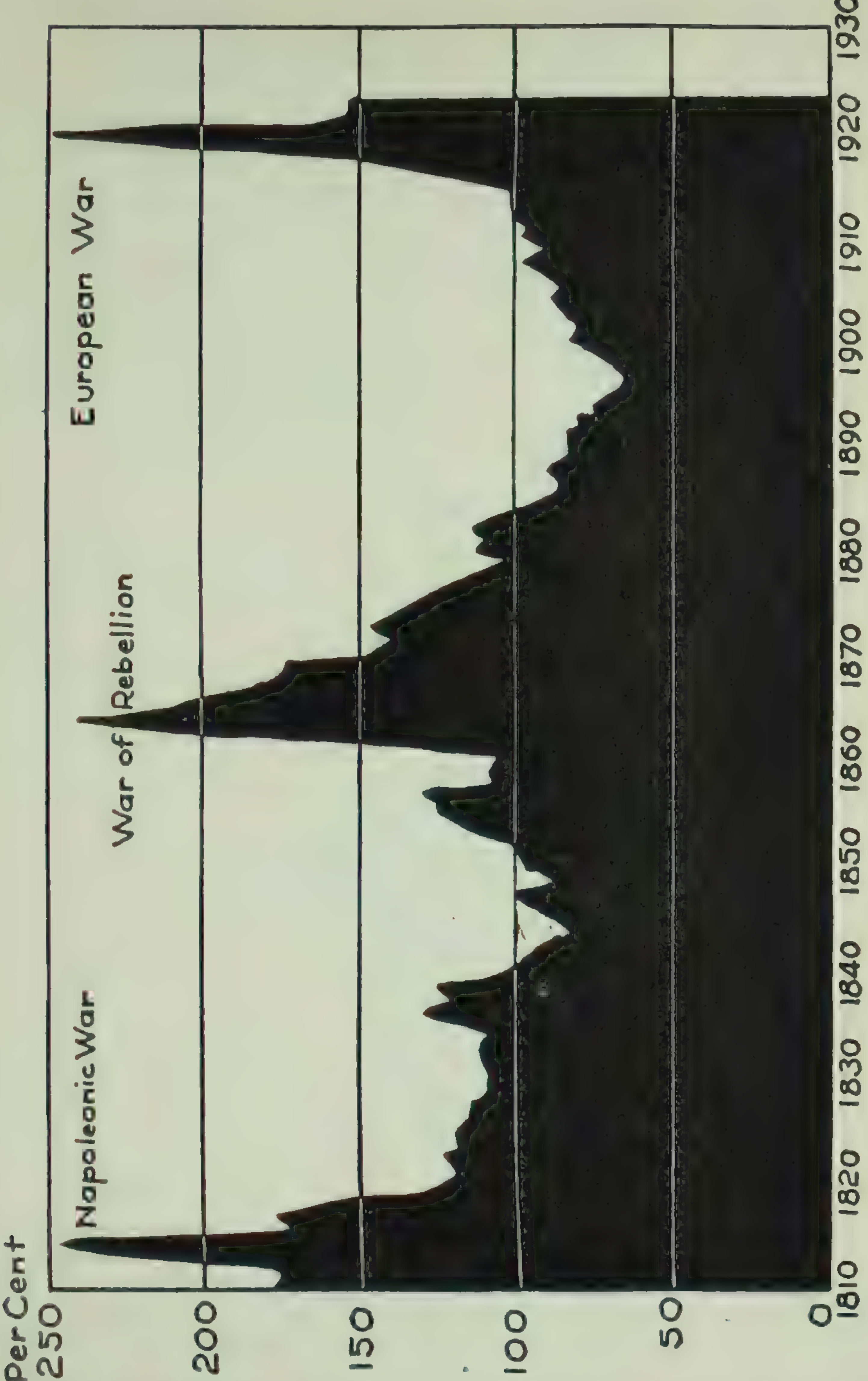


Fig. 71. Price Averages for 112 Years, Showing Periods of Great Wars

Average for 1914 taken as 100 per cent. (From a chart reproduced in *The Iron Trade Review.*)

Two-way curves. An illustration of measurements both above and below a base line is shown in Figure 72. The method is similar to that illustrated for vertical bars in Figure 48. The upper scale represents immigration, the lower emigration. The data are based on changes in the population of Iowa, by ages, for a five-year period. The age scale reads from left to right along the bottom of the chart. The base line, representing zero in number of persons, runs horizontally through the center. The curve, inked in solidly, indicates the frequency for each age. Although the ages are shown in intervals of ten years, the data are actually compiled for year periods. The rounded effect is produced by "smoothing" the curve, a device often used in statistical presentations in which the general tendency is to be stressed.

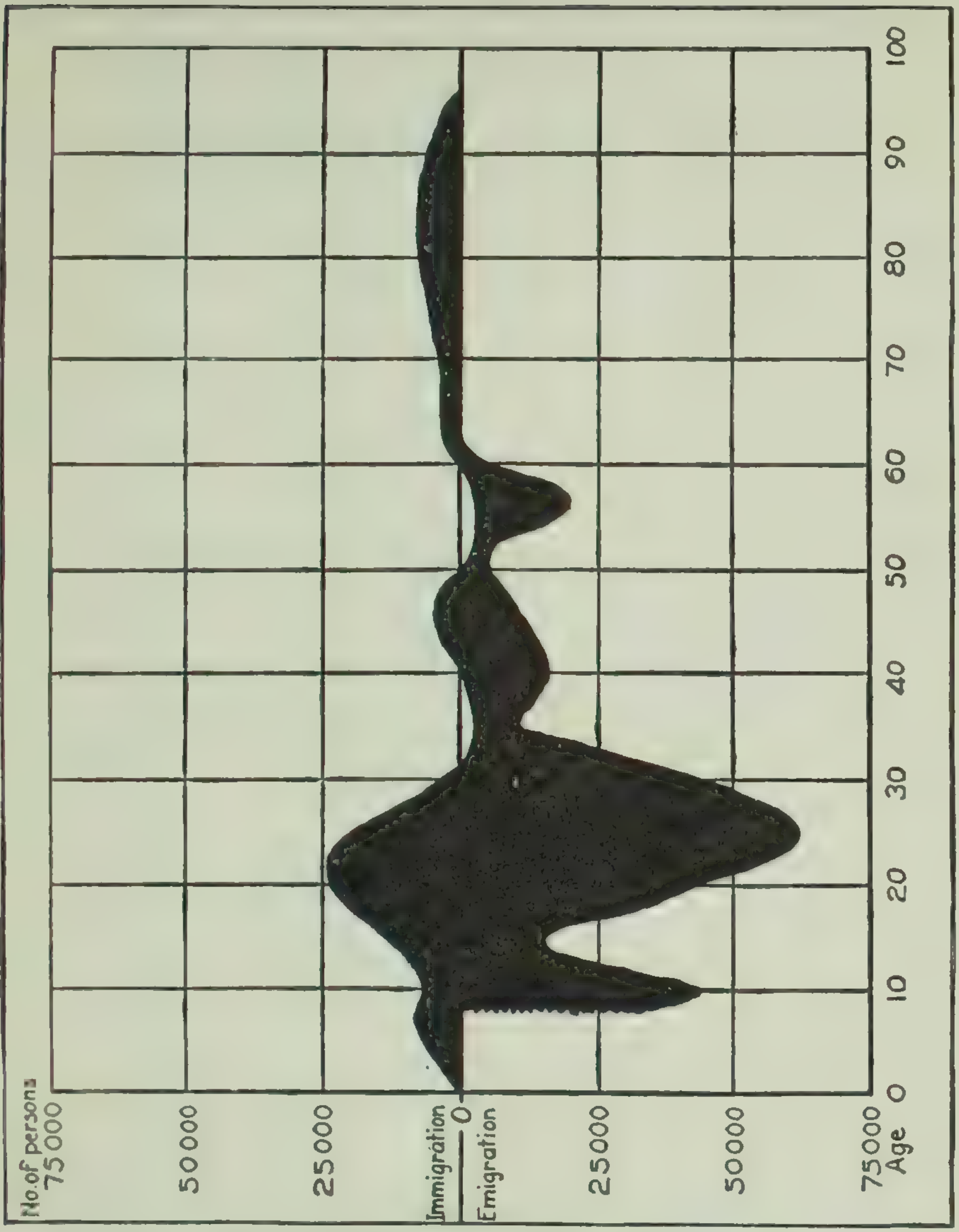


Fig. 72. Age Distribution of Iowa Migrants, 1900–1915
(From *Selective Migration as a Factor in Child Welfare in the United States*, by Hornell Hart.)

PROBLEMS FOR CHARTING

1. Draw a cumulative curve, as in Figure 60, based on the growth of the school population of your city during the past fifteen years. Choose guide-line intervals according to the amount of space required to show the highest value.
2. Draw the profile curve (Figure 62) for a boy who scores in the will-temperament test as follows:

Test	Score	Test	Score
I	3	VII	5
II	8	VIII	6
III	5	IX	9
IV	7	X	9
V	10	XI	7
VI	8	XII	5

3. Obtain recent infant mortality data from reports of the United States Children's Bureau, and show the present conditions in the form of Figure 65.
4. Make a comparative-curve chart, following the plan of Figure 67, from the data shown in Figure 46.
5. Chart the results of tests for the following data, using the form of Figure 68, and the same comparative norm-curve:

Test Ratings for Jefferson School

Grade	Quality	Rate
3	44	42
4	46	53
5	48	60
6	50	65
7	52	75
8	55	80

6. Experiment with the use of white lines, by redrawing Figure 71 with vertical lines to represent the ten-year intervals.

CHAPTER VII

FREQUENCY SURFACES

(EXPLAINING FIGURES 73 TO 76, INCLUSIVE)

General definition. The frequency surface, or "histogram," as it is sometimes called, is really a group of adjacent vertical bars, so drawn that they make up a single body of a characteristic steplike form. It differs from a bar chart in that its main purpose is to show the *frequency trend* of a series of intervals, rather than to emphasize the *volume* of single intervals. Growth and diminution are indicated by the appearance of the steps, which rise or fall according to the relative size of the measures.

The frequency surface differs from the curve chart in that each interval is represented by a *space*, instead of by a *line*. In a curve chart a line representing an interval of 85 to 89, for example, has a value equal only to the mid-point of the interval, or 87.5 on the horizontal scale. In a frequency surface the entire interval is shown, although it may be indicated numerically by the value of its mid-point. Any of the charts illustrated in this chapter could be drawn as vertical bars or curves, by finding the mid-point on each "step" and connecting the points with a line.

The general rules for charts of this type are the same as for bars and curves; the vertical scale is shown at the left, the horizontal scale at the base, and appropriate intervals.

Simple-frequency surfaces. Figure 73 illustrates the simplest type of frequency surface. In order that its structure and resemblance to a series of columns may be observed, all vertical lines bounding the steps are extended downward to the base. Although the extension is not necessary, it nevertheless serves to define the intervals and to emphasize the relation between the designating numbers and the steps. Charts are especially subject to lack of clarity in this respect when the steps are narrow, and when they rise to considerable height above the base line. These facts should be kept in mind in planning the chart.

Inasmuch as each step represents a percentage value in relation to the entire group, the combined value of the steps is 100 per cent. This chart shows the intelligence-quotient distribution of the unselected school children on which the Stanford Revision of the Binet-Simon Intelligence Scale is based. It has been extensively used for comparison in reports of test experiments and surveys. The exact data are as follows:

I.Q.	Per Cent
136–145	0.55
126–135	2.30
116–125	9.00
106–115	23.10
96–105	33.90
86– 95	20.10
76– 85	8.60
66– 75	2.30
56– 65	0.33

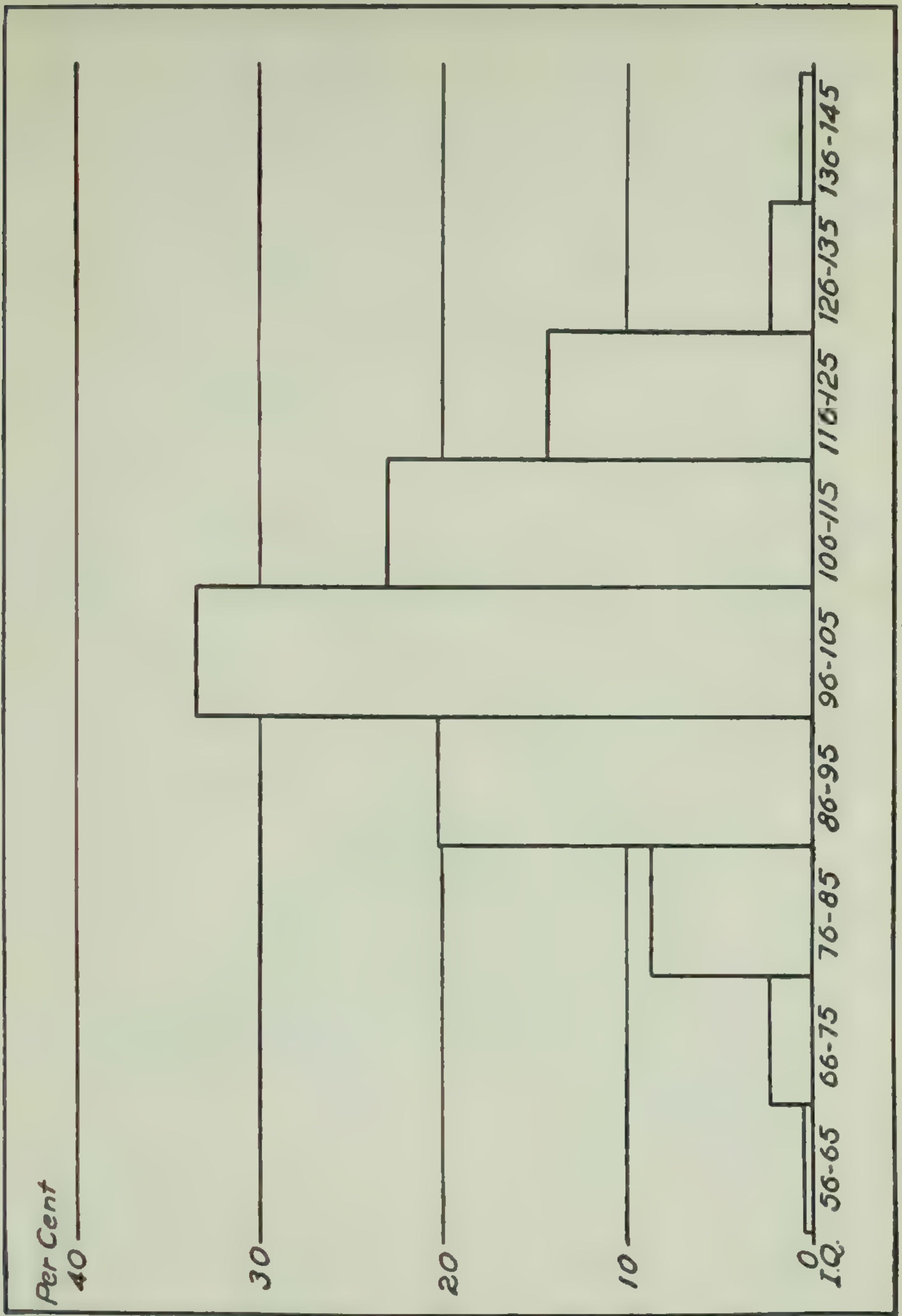


FIG. 73. DISTRIBUTION OF INTELLIGENCE QUOTIENTS OF 905 UNSELECTED SCHOOL CHILDREN
(From *The Measurement of Intelligence*, by L. M. Terman.)

Shaded frequency surfaces. Figure 74 shows a frequency chart in which the area enclosed by the surface and the base line is shaded. This causes the shape of the histogram to stand out prominently, and emphasizes the differences between adjacent levels. The purpose of the chart is to show the age-distribution of the children in the fourth grade of a city school system, all the fourth grades being combined so that the entire age-range could be determined. The horizontal scale is laid off in intervals of one-half year, each interval being represented by its mid-value; thus the first age-level, 7.5, includes ages 7.3 to 7.7 years; the 8.0 interval includes ages 7.8 to 8.2 years, etc. The cases are assumed to be evenly distributed through each interval, hence the horizontal character of the steps.

The use of this chart in connection with the report of a school survey helped to bring out the enormous age range of the pupils, and the extent of the slow progress being made. Children over eleven years of age, who are still in the fourth grade at the end of the school year, are seriously retarded. The chart clearly shows how the over-ageness extends up to the 14-year level.

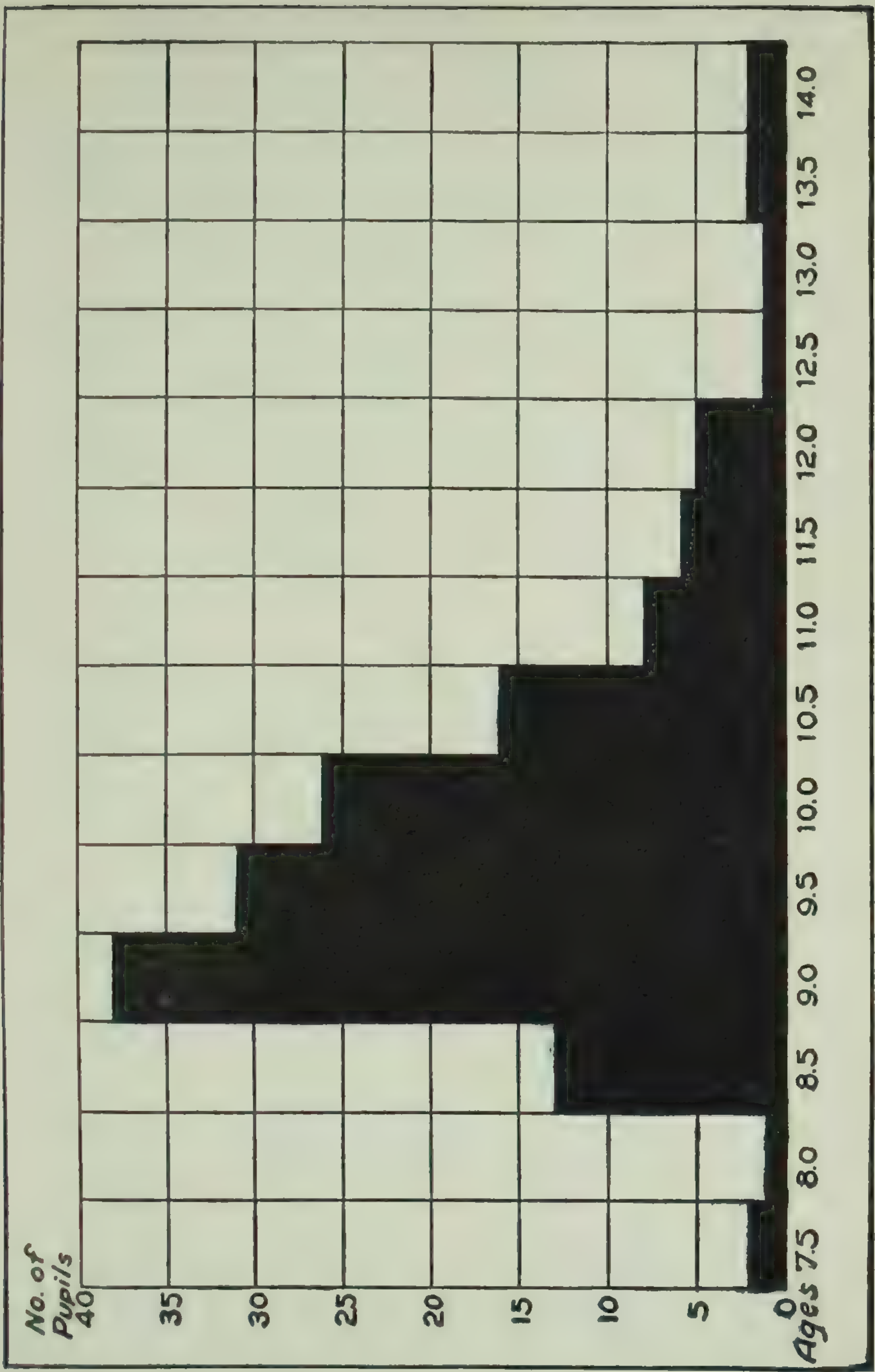


FIG. 74. AGE DISTRIBUTION OF PUPILS IN GRADE 4a, BOISE PUBLIC SCHOOLS
(From *The Boise Survey*, by J. B. Sears.)

Comparative frequency surfaces. Figure 75 shows the comparative distribution of two series of measures, in a manner similar to the curve distribution illustrated in Figure 66. In this case the data are obtained from intelligence tests of a group of delinquent boys in a state industrial school. The chronological age (represented by continuous line) shows that the boys range from 6 to 22 years. In mental age (dot line) they resemble a group much younger, ranging from 5 to 18 years. The median chronological age is 16 years, the median mental age, 12 years. These central measures, which divide each of the groups into two equal parts, are indicated by vertical lines marked "M." Note that each median line is constructed to correspond with the frequency surface which it represents, and with the key, shown in the upper right-hand corner.

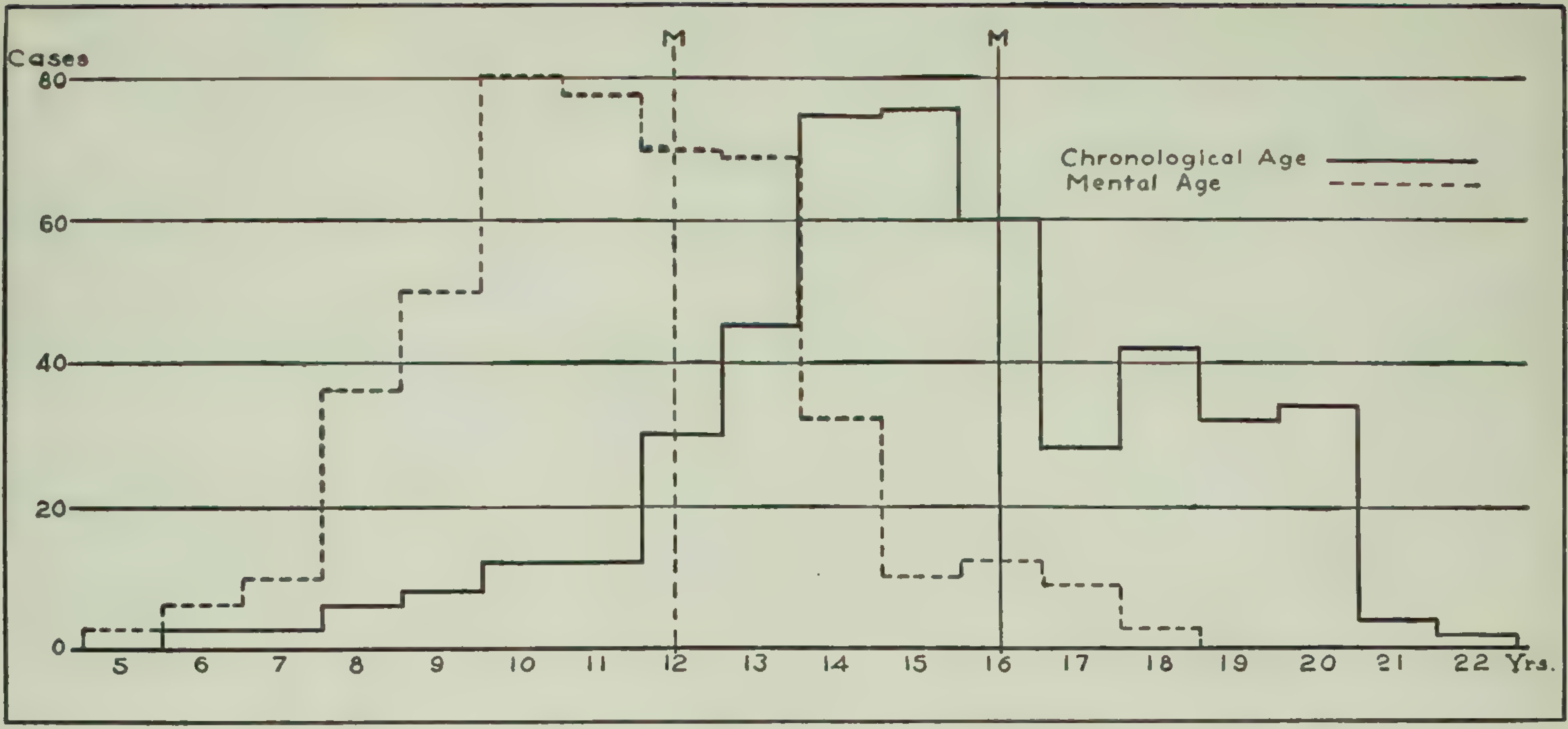


FIG. 75. DISTRIBUTION OF CHRONOLOGICAL AND MENTAL AGES OF 470 DELINQUENT BOYS
(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

Two-way frequency surfaces. Figure 76 illustrates the principle of two-way vertical distribution applied to a frequency-surface chart. The deviations in this case are not measured from zero, as in Figure 72, but from another line which represents the central tendency of the combined groups. Another central measure, the standard score, is also used for comparison, and is represented by a dot line.

The upper frequency surface represents, for each school, the highest score made by any grade. The grade winning this distinction is enumerated on each step. Thus in the Central School, the fifth grade made the highest score, 93; in the Garfield School, the seventh grade made the highest score, 87. The lower frequency surface shows, in a similar manner, the lowest score made by each school. Thus in the Central School the third grade made a score of 64; in the Garfield School the fourth grade made a score of 72. The average for all the schools is 79, which is 6 points above the Ayres standard. The median for each school is shown by a thin dot line marked "M." For the Central School the median is 82; for Garfield, 76, etc. The chart shows that the spelling ability of the Boise pupils is considerably above the Ayres standard, only one school (Lincoln) falling slightly below.

Inasmuch as the portion of the vertical scale between zero and 50 per cent is not used, the space is conserved by the separation method, as previously explained, and as indicated by the waved-line effect at the bottom of the chart.

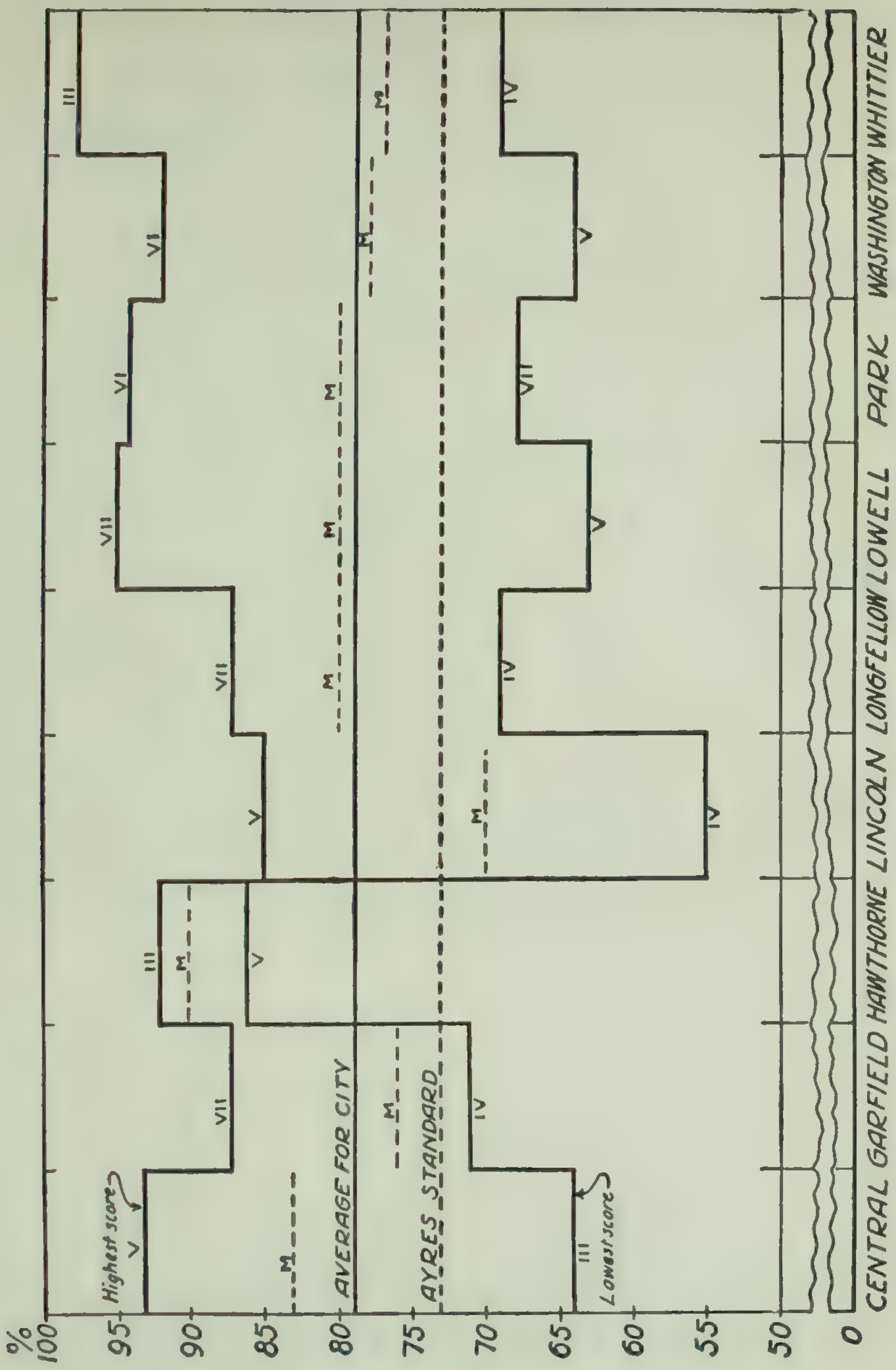


FIG. 76. RESULTS OF APPLICATION OF AYRES SPELLING TEST IN BOISE PUBLIC SCHOOLS

(From *The Boise Survey*, by J. B. Sears.)

PROBLEMS FOR CHARTING

1. Chart the following table on the plan of Figure 73:

INTELLIGENCE QUOTIENTS OF A GROUP OF RAPID-PROGRESS PUPILS

I.Q.	No.	I.Q.	No.
150–155	2	120–124	35
145–149	3	115–119	30
140–144	5	110–114	26
135–139	7	105–109	15
130–134	10	100–104	7
125–129	25	95–99	3

2. Following the plan of Figure 74, show the following data, taken from the same school survey:

GRADE DISTRIBUTION OF BOISE PUBLIC SCHOOL PUPILS
TEN YEARS OF AGE

Grade	No.	Grade	No.
VI A	8	III A	26
VI B	20	III B	13
V A	65	II A	8
V B	61	II B	3
IV A	59	I A	3
IV B	43	I B	0

3. Chart the following table as a comparative frequency distribution, as in Figure 75:

CHRONOLOGICAL AND MENTAL AGES OF ONE HUNDRED SPECIAL CLASS PUPILS

Years	C.A.	M.A.
13	1	0
12	6	3
11	12	5
10	18	10
9	30	25
8	20	35
7	10	26
6	3	4

4. Following the plan of Figure 76, chart the following data:

School	Average Score	Highest Score		Lowest Score	
		Grade	Score	Grade	Score
Jefferson	76	IV	85	III	70
Adams	70	V	80	VI	65
Brown	82	VII	96	VIII	68
Borden	75	VII	78	V	70

CHAPTER VIII

INDIVIDUAL FREQUENCY DISTRIBUTIONS

(Explaining Figures 77 to 86, Inclusive)

General definition. In most of the preceding charts the cases under consideration have been grouped, so that their general trend or their central values might be observed. In this chapter we will deal with methods of charting in which each case is indicated by a separate area or mark. In the frequency surface illustrated in Figure 75, for example, the step valued at 10 years includes 80 boys. These boys are not all exactly ten years of age, but range from 9 years 6 months to 10 years 5 months, inclusive. They are grouped, for convenience in comparison, under conditions in which the finer age differences are of minor importance. In an individual frequency distribution the exact age and mental age of each boy would be shown. Such a chart, constructed from the same data, is shown in this chapter.

Individual frequency distributions are most frequently used for representing a small number of cases, and for emphasizing the value of individual cases or items. They also have a greater display value than group charts, and lend themselves well to discussions centering about individual differences.

Simple individual frequency distributions. Figure 77 illustrates the use of dots, or "spot chart" frequencies. This chart, based on a school survey of physical conditions, shows the number of children found suffering from certain physical defects. The principal idea conveyed is that many of such cases were found; and that defective teeth were found more frequently than the five other defects shown. The dots, each representing one child, are distributed evenly through the respective areas, without regard to exact measurement. Where the number of cases is large, as in the first square, the density is plainly shown. The contrast between any two of the remaining squares, however, is not sufficiently marked to enable one to form a correct idea of the difference in frequency. By using numerals to indicate the exact number of cases the value of the chart is somewhat improved. Without the numbers it might be misleading. The chief limitation of the chart is that no comparison is made with the total number of children examined.

The dots and numerals for this chart were made with the Esterbrook lettering-pen No. 1.

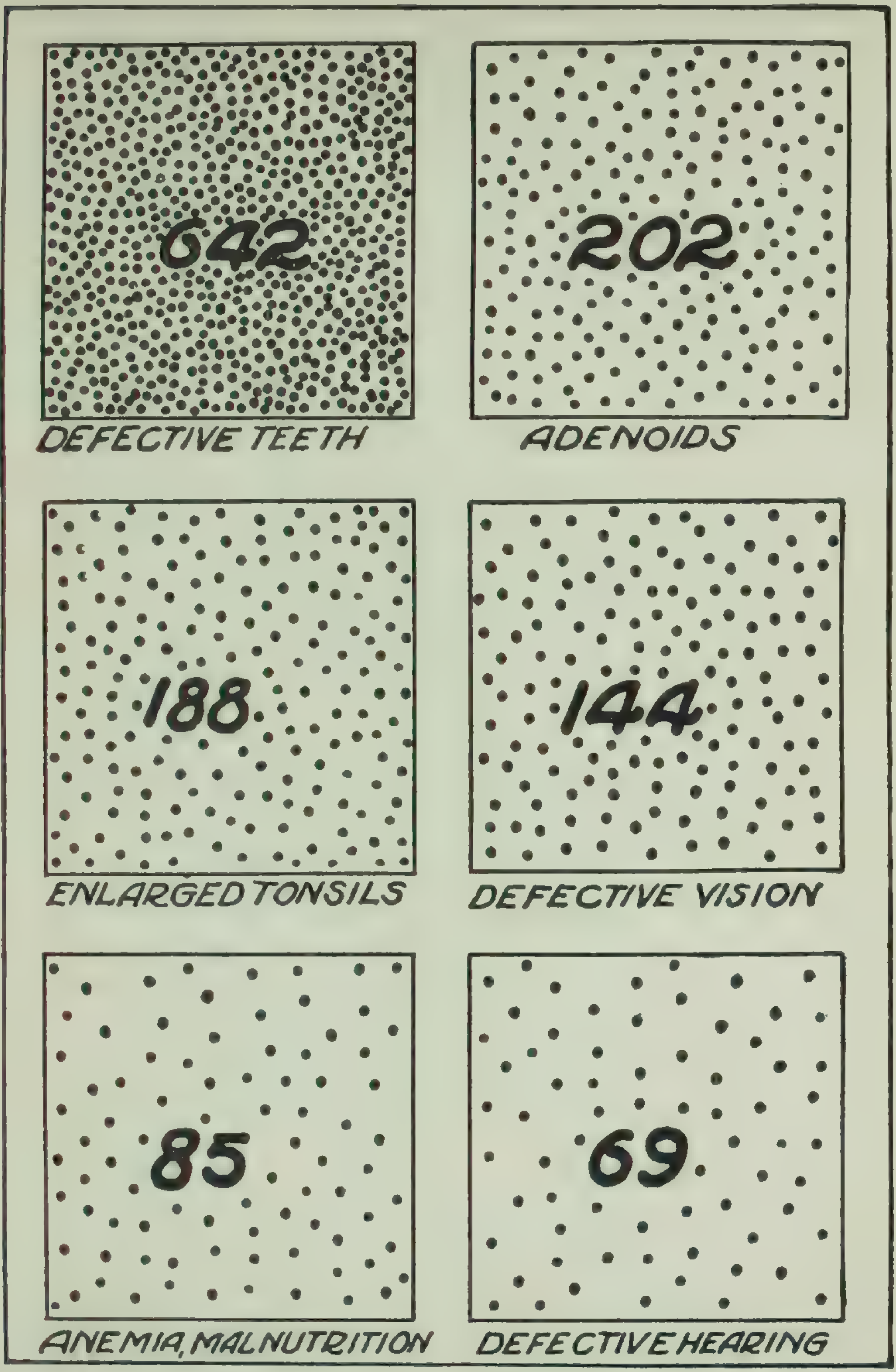


FIG. 77. PARTIAL FINDINGS OF PHYSICAL EXAMINATIONS OF 2229 SCHOOL CHILDREN IN ELYRIA, OHIO

(Data from United States Bureau of Education Bulletin no. 15. 1918.)

Percentage distributions. Figure 78 is not exactly an individual frequency distribution, but belongs in this classification because the items are broken up into units of measurement. Each full circle represents one hundred dollars. The partly filled circles represent the proportionate amounts measured by sectors. For example, the salary of janitor "A," $1260, is represented by twelve full circles and a 60 per cent sector. Note that the circles are grouped in fives, counting from left to right.

Although perhaps the chief value of this chart is its spectacular character, it has been drawn with regard for the standard rules of graphic presentation, among which are illustrated the following:

1. It shows exactly what it claims to show, without misleading effects.
2. The designation of each item is plain.
3. The parts are evenly spaced and clearly inked.
4. The lettering is distinct, and of appropriate size.
5. The scale is shown at the bottom.
6. The exact value of each item is given numerically.
7. The median value is shown, both numerically and graphically.
8. The border is drawn with regard to conservation of space.

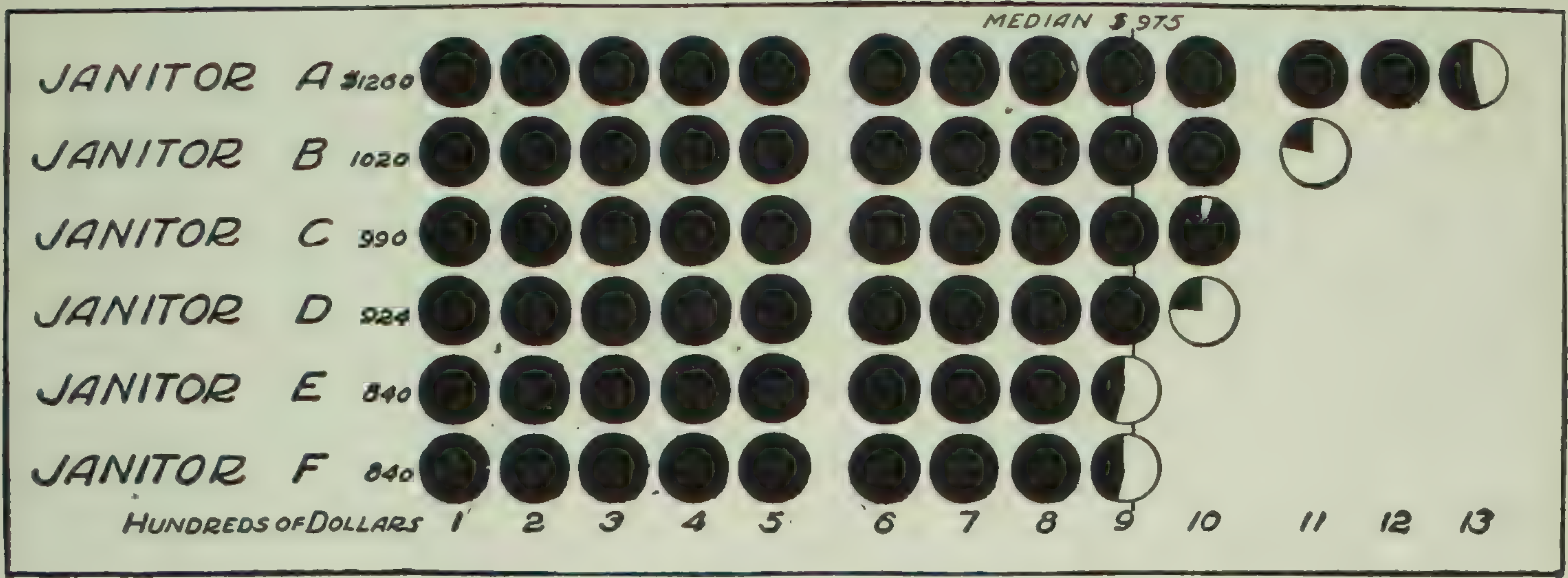


FIG. 78. SALARIES OF SCHOOL JANITORS IN ELYRIA, OHIO
(Data from United States Bureau of Education Bulletin no. 15. 1918.)

Age-grade distribution. The distribution of colored children in a city school system is shown in Figure 79. Each circle represents one child. The small number of cases and irregularity of the frequencies make this type of chart, for such data, of greater value than a frequency surface or a bar diagram. Note that horizontal guide lines are used, passing through each fifth circle. Note also that the frequencies may be seen in relation to the entire range of grades.

The tabular data from which the chart was drawn are as follows:

Grade	No.	Grade	No.
I	24	VII	8
II	16	VIII	2
III	13	IX	6
IV	21	X	1
V	15	XI	2
VI	1	XII	0

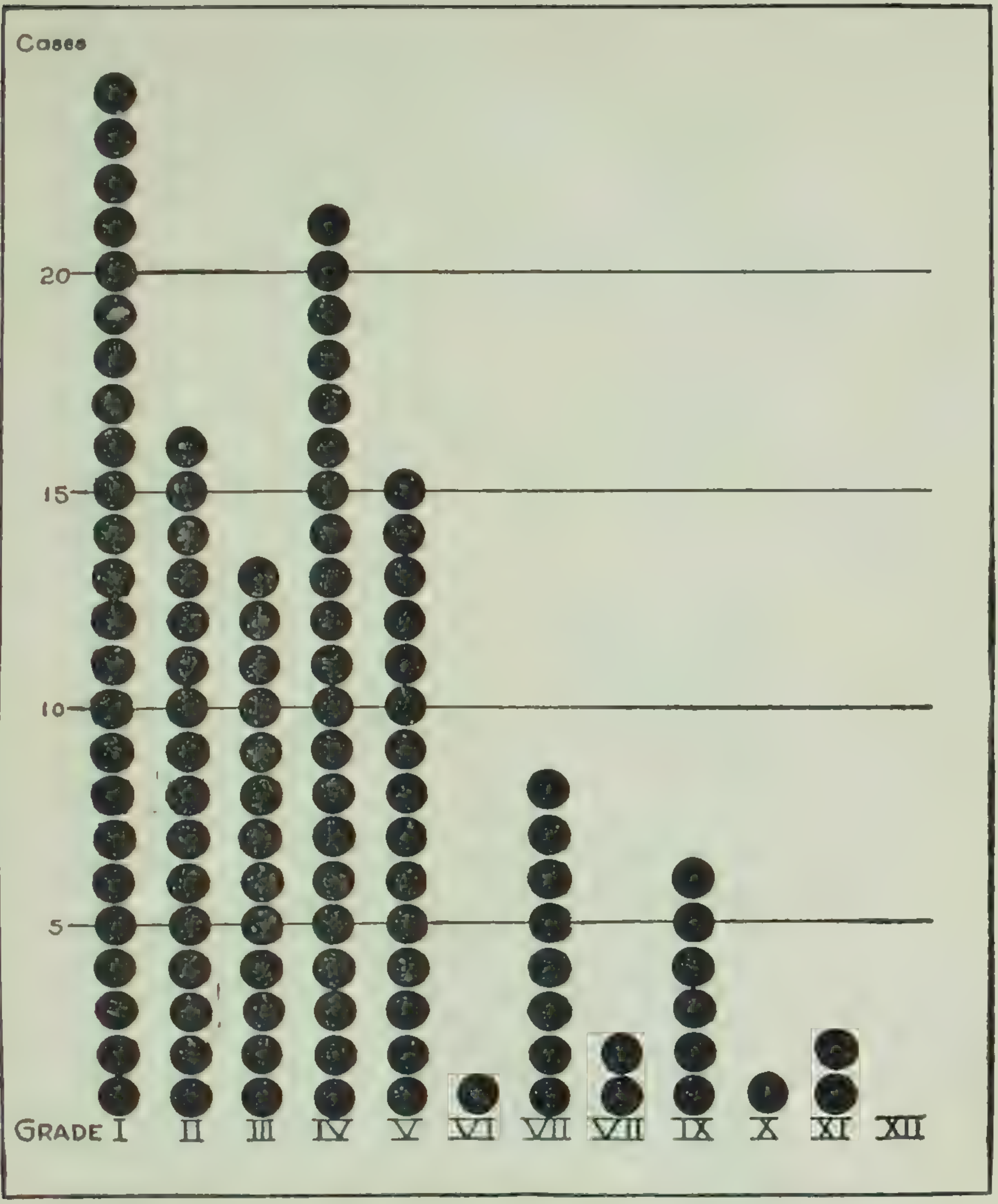


FIG. 79. GRADE-DISTRIBUTION OF COLORED CHILDREN IN GALESBURG, ILLINOIS

(From data in *Annual Report of Galesburg Public Schools.*)

Individual frequency surfaces. Figure 80 is an irregular frequency-surface laid off into single units. Each square represents one child, and his position on the horizontal scale indicates his gain in weight as a result of a school-feeding experiment. The vertical scale is not given, because of the small number of cases, and the ease with which the blocks may be counted. The heavy zero line is at the left, and the guide lines run parallel with it in intervals of 25. The 100 per cent interval is especially emphasized by dropping the numerals below the line of the scale. The median gain is 220 per cent, which is not one of the intervals, but is shown in line with 100 per cent. Because of the striking character of the facts shown, and the significance of the separate gains, the choice of the individual frequency distribution for such data is highly appropriate. In the original chart the effect was made more striking by the use of white horizontal and vertical lines through the inked-in area.

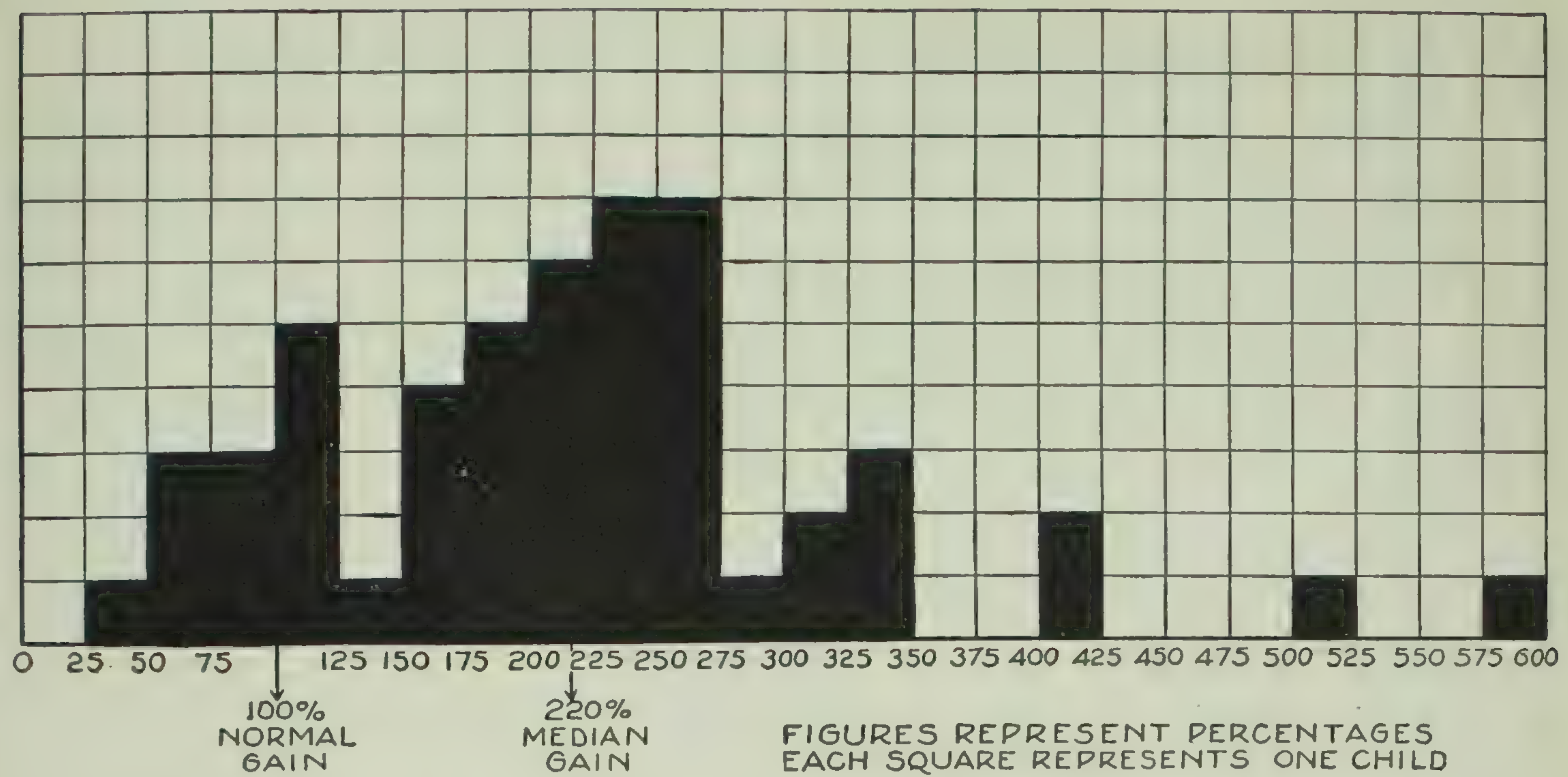


FIG. 80. RESULTS OF SCHOOL FEEDING OF 52 CHILDREN IN NEW YORK CITY FOR 16 WEEKS
(From *Malnutrition and School Feeding*, United States Bureau of Education Bulletin no. 37. 1921.)

Individual designation charts. The individual frequency surface shown in Figure 81 has for its special purpose the designation of certain cases, in consequence of the differences between intelligence ratings obtained from two tests. The cases, or pupils, each represented by a square, are distributed according to the results of the first test, in intervals of five points on the horizontal scale at the base. On each square appears the exact rating by both tests. For example, the lowest pupil scores 34 points in the first test, and 80 in the second; the highest pupil scores 75.5 in the first and 153 in the second. The two heavy lines drawn through the center of the chart separate the pupils into three equal groups (tertiles). A redistribution of scores after the second test revealed that seventeen pupils had shifted their tertile rank; and these displacements are indicated by the shaded areas. For example, the third pupil from the left, originally in the first tertile group, secured a score which displaces his rank to the middle group. Although the interpretation of the chart is somewhat complex, it is an accurate and reliable presentation of the data.

The numbering on the chart was done on the typewriter, before the penciled lines were inked in. The displaced cases are shown by single-hatching, care being taken to "skip" the numerals.

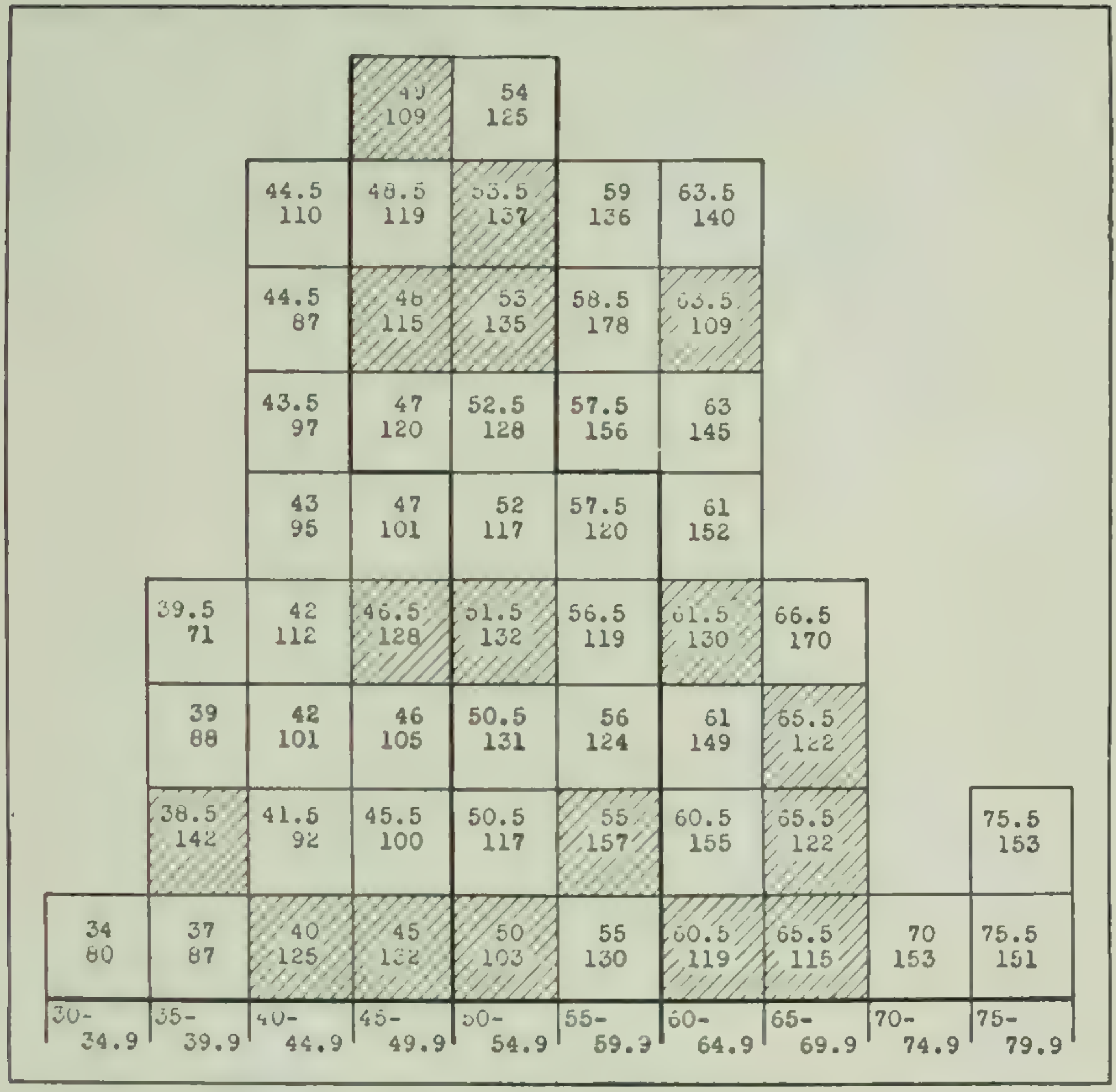


FIG. 81. DISPLACEMENTS IN TERTILE CLASSIFICATION DUE TO DISPARITY BETWEEN TWO INTELLIGENCE TESTS

Numbers represent Chicago and Terman group tests, respectively. Displaced cases indicated by shading. (After Breed and Breslich, in *School Review*, January, 1922.)

Special grouping charts. Figure 82 is based on the data shown in Figure 79 — the distribution of colored school children. Here they are distributed not only by grades, but by separate schools. Each school in the city is represented, although two of them (East Losey Street and Douglas) have no colored pupils enrolled. The arrangement of schools is based on the highest grade reached by the colored children. After each school a rectangle is placed for each grade to be represented. The dots are evenly distributed in these areas, and, because most of the frequencies range from one to six, a striking domino effect is produced.

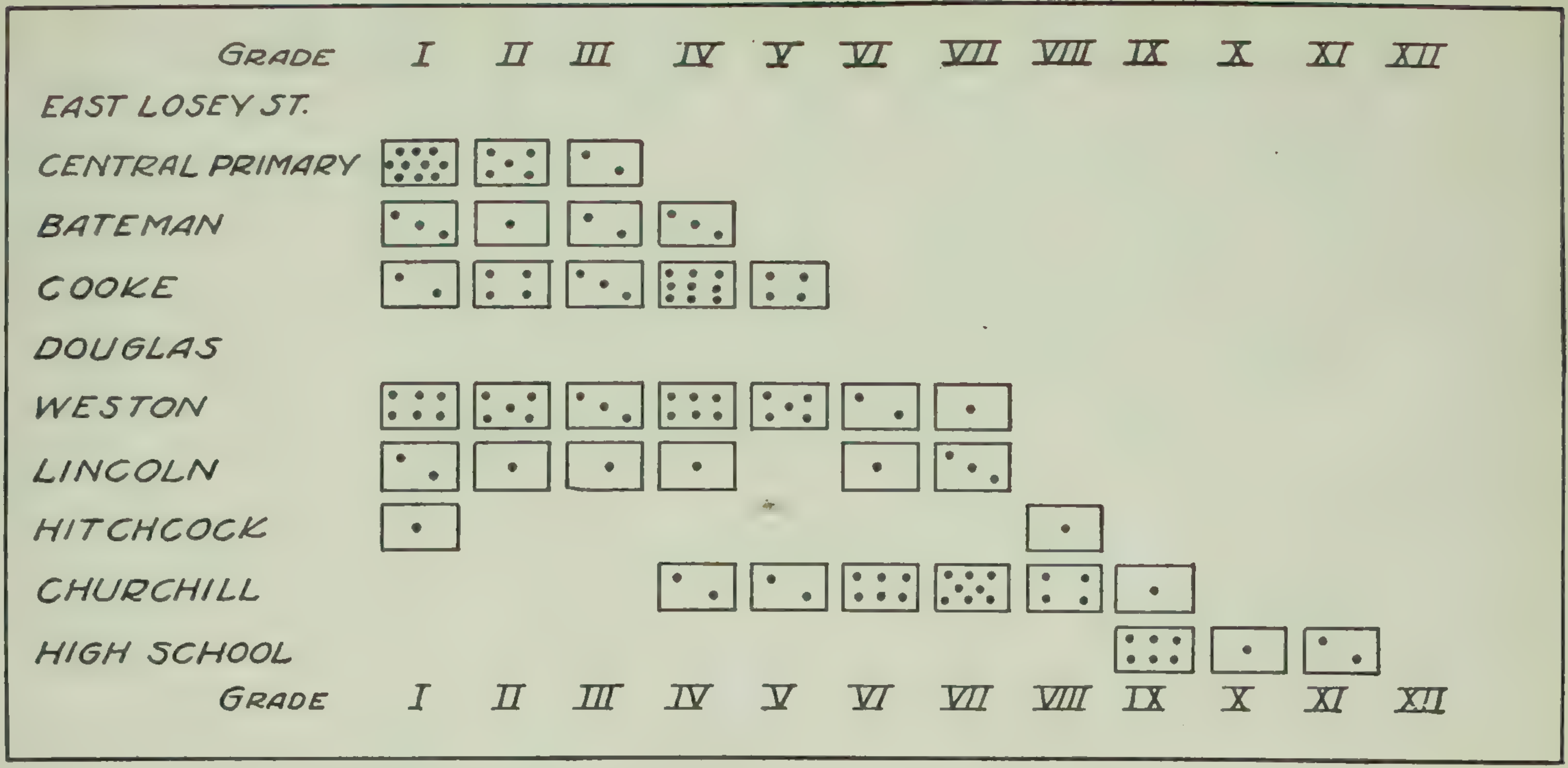


FIG. 82. DISTRIBUTION OF COLORED CHILDREN IN GALESBURG, ILLINOIS, BY SCHOOLS AND GRADES
(From *Annual Report of Galesburg Public Schools.*)

Double-scale frequency distributions. Figure 83 illustrates the individual method of representing the 470 chronological ages and mental ages which comprised the data for the comparison in Figure 75. In this case, however, a dot is placed on the chart for each boy in such a position that it represents his status on both age scales. Chronological ages are shown in the horizontal scale at the bottom; mental ages appear at the left. Measurements on each scale are made from a heavy zero line. The following examples will illustrate the manner in which the dots are placed: The highest dot represents a boy whose chronological age (horizontal scale) is 18 years 6 months. That he is the brightest boy in the group is indicated by the superior position of the dot in comparison with the others. The youngest boy shown (lower left) is six years of age chronologically and has a mental age of 5 years 7 months. The placing of the dots between the lines is done by visual estimation, and cannot be exact because of the size of the dot. Theoretically the center of each dot is at the exact position desired.

In order to increase the comparative value of the chart a heavy diagonal line is drawn from the zero points which intersects the point of intersection of horizontal and vertical lines of the same value. This is continued up to the sixteen-year level (average adult on Stanford-Binet Scale), beyond which chronological age is disregarded in determining relative mental status. Intellectual superiority and retardation are indicated by the extent to which each dot deviates above or below the diagonal line. A dot line, representing a retardation of 25 per cent, or an intelligence quotient of 75, is shown below the heavy diagonal. This represents the upper limits of mental deficiency, according to the classification used in the study from which the chart is taken. Approximately 30 per cent of the boys shown here were considered mentally deficient.

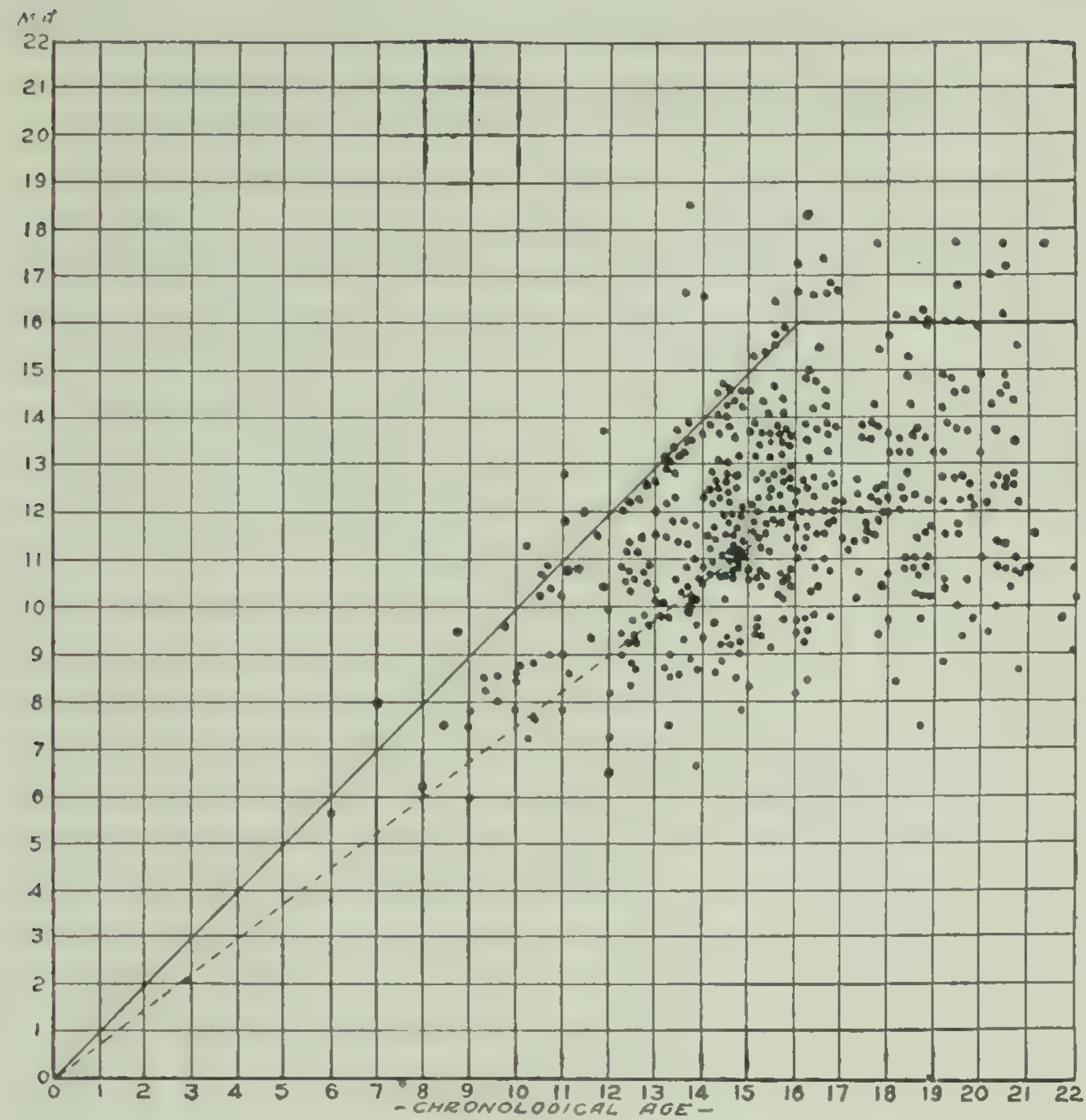


FIG. 83. CHRONOLOGICAL AND MENTAL AGES OF 470 DELINQUENT BOYS
(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

Another double-scale frequency distribution. Figure 84 shows the results of a study of vocational training achievement in relation to mental age. Each dot represents one boy, the position of the dot indicating his trade rating (horizontal scale, numerals at the top) and his mental level (vertical scale at left). The dot farthest to the left, for example, represents a mental age of 13.8 years and a trade rating of 1.6 points. The totals for each group are shown at the right and bottom, respectively. A heavy vertical line shows the median rating (3.5 points), and heavy horizontal line shows the median mental age (12.3 years). Vertical dotted lines show the first and third quartiles, between which are included the middle half of the cases, according to rating. The correlation is positive, indicating a general correspondence between intelligence and trade rating, but the individual differences are extreme, as may be judged from the scattering of the dots.

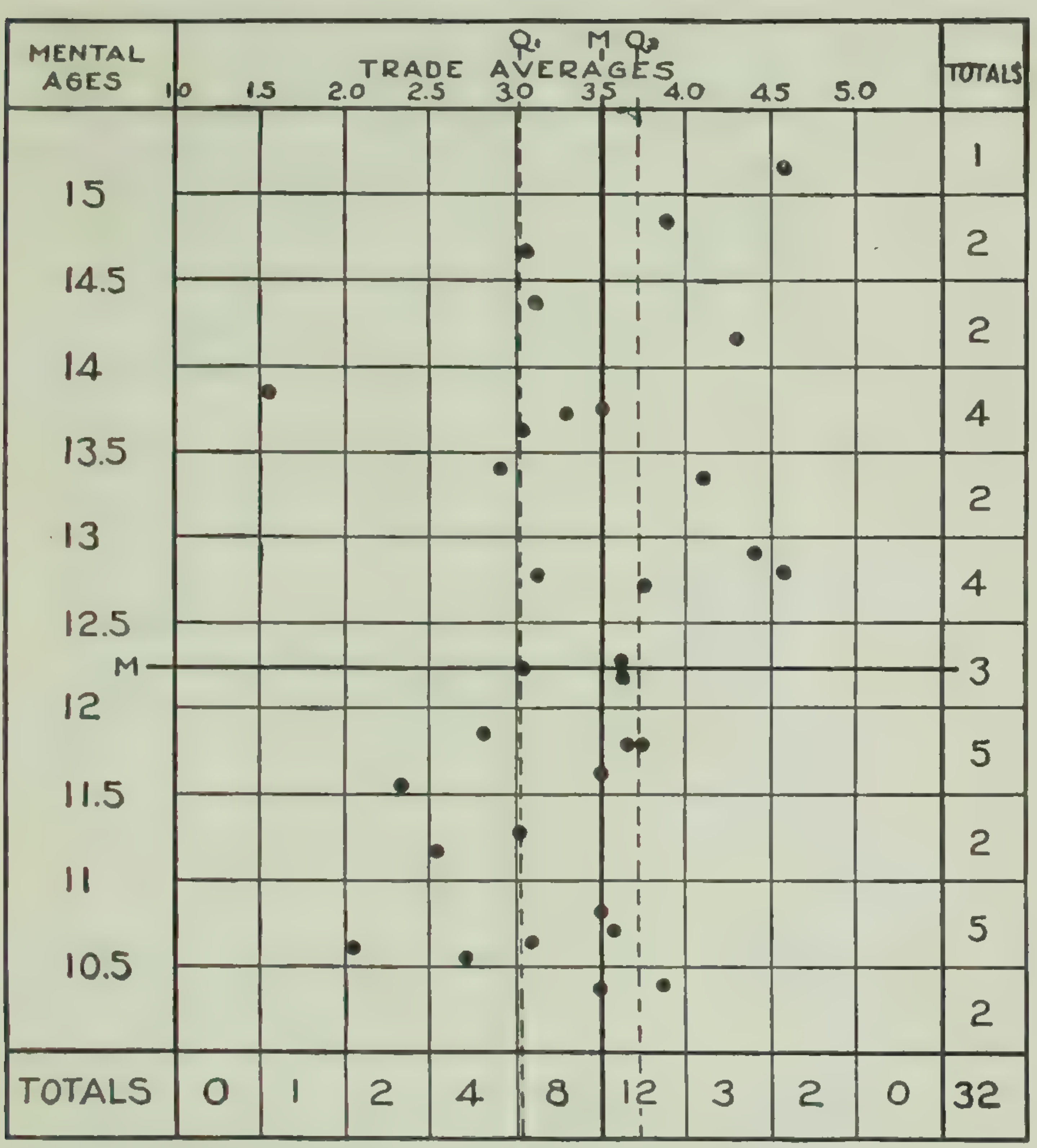


FIG. 84. RELATION BETWEEN INTELLIGENCE AND ACHIEVEMENT RATINGS IN MANUAL TRAINING

(After K. M. Cowdery, in *Journal of Applied Psychology*, April, 1923.)

Individual positions in grouped series. Figure 85 is a graphic representation of results obtained from a study of success in salesmanship, in relation to intelligence. The composite test scores, on the horizontal scale, range from -11 to $+24$ points. The vertical scale is not measured numerically, but according to five degrees of success, arranged in descending order from the highest. It will be observed that there is a close correspondence between the two measures. It is especially significant that the unsuccessful salesmen made consistently inferior scores in the test. Although the relationship could have been shown with plain circles, the effect is made more striking by the use of filling and shading, the explanation of which is given in the key.

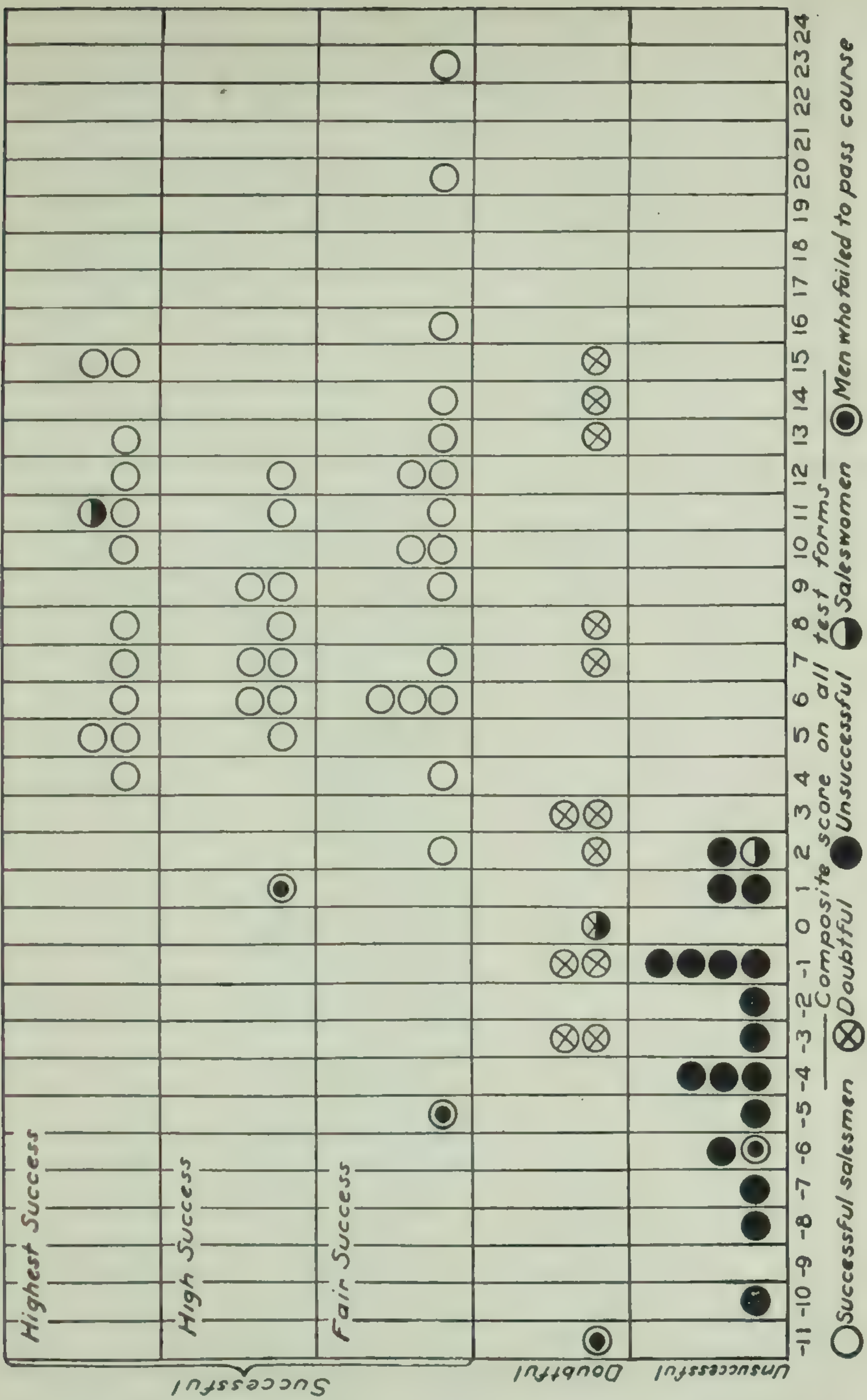


FIG. 85. RESULTS OF PSYCHOLOGICAL TESTS OF INSURANCE SALESMEN IN RELATION TO THEIR SUCCESS

(After C. S. Yoakum, in *Journal of Personnel Research*, May, 1922.)

Another individual classification form. Another form of individual classification is shown in Figure 86. Each circle represents one boy; its position on the horizontal scale shows the intelligence quotient, and the filling or shading represents the classification, according to the key. The intelligence quotients range from 47 to 135. All cases of a given I.Q. are placed on a vertical line, and equally distributed from the horizontal center. In laying out the chart, a penciled line was drawn for each I.Q., and the circles centered on it with the bow-pen. Vertical guide lines are retained in intervals of 10.

The purpose of the chart is to show the relationship between the test score and the social-intelligence classification, which was made in each case after analysis of supplementary data. There is a noticeable overlapping of groups, as for example, in the case of the feeble-minded boy whose I.Q. is 78; the "average-normal" boy whose I.Q. is 84; and the "superior" boy whose I.Q. is 106. This presentation of the data helps to emphasize the importance of supplementary test findings with reliable information from other sources, where individual classification is desired.

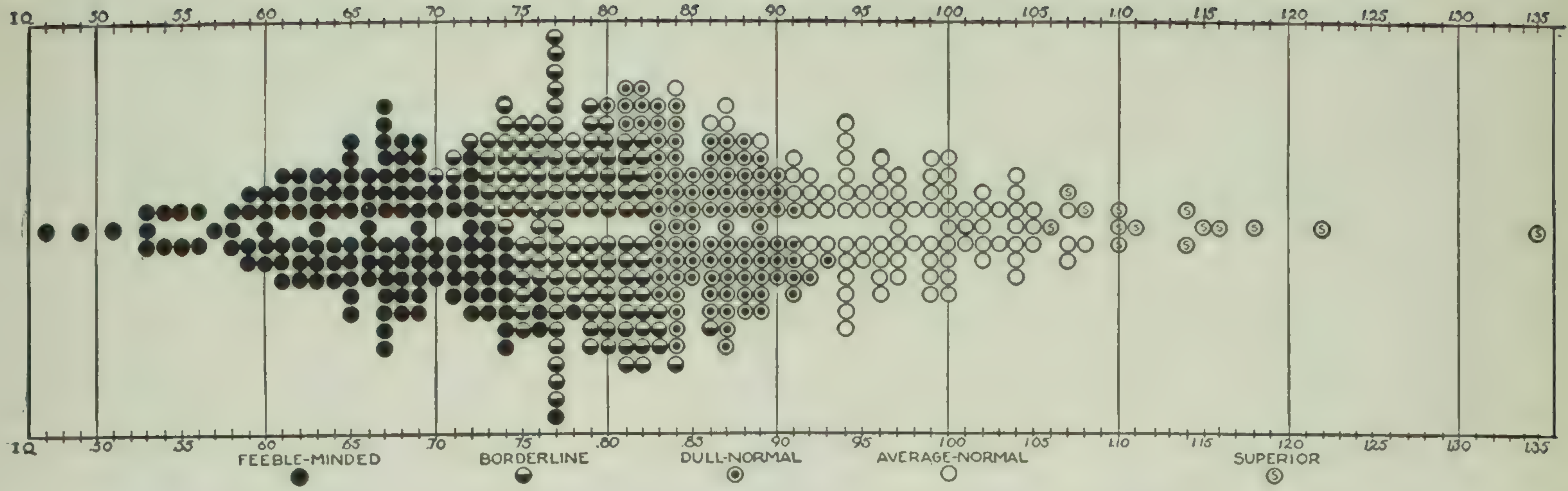


FIG. 86. INDIVIDUAL DISTRIBUTION OF INTELLIGENCE QUOTIENTS AND SOCIAL-INTELLIGENCE CLASSIFICATION OF 470 DELINQUENT BOYS

(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

PROBLEMS FOR CHARTING

1. Chart the following data, according to the plan of Figure 77:

PERCENTAGE OF SCHOOL CHILDREN OF DIFFERENT AGES HAVING NO WINDOW OPEN AT NIGHT

(From a survey reported in *The Hygiene of the School Child*, by L. M. Terman)

AGE	PER CENT	AGE	PER CENT
6	40	13	17
7	38	14	10
8	28	15	14
9	28	16	5
10	25	17	6
11	26	18	2
12	20		

2. Chart the following on the plan of Figure 78:

MEDIAN SALARIES OF TEACHERS IN BOISE SCHOOLS, 1919

(From *The Boise Survey*, by J. B. Sears)

	1917	1918	1919
High-school teachers	$1000	$1200	$1250
Elementary-school teachers	870	885	980

3. Chart the following on the plan of Figure 78:

GRADE LOCATION OF 263 ELEVEN-YEAR-OLD CHILDREN

(From *The Intelligence of School Children*, by L. M. Terman)

GRADE	NO.	GRADE	NO.
I	4	V	110
II	8	VI	56
III	21	VII	15
IV	47	VIII	2

4. Chart the following data on the plan of Figure 79:

DISTRIBUTION OF AGES OF 136 LOW-TENTH-GRADE BOYS

(From *Mental Tests and the Classroom Teacher*, by V. E. Dickson)

AGE	NO.	AGE	NO.
13-1 to 13-6	2	16-1 to 16-6	15
13-7 to 14-0	1	16-7 to 17-0	8
14-1 to 14-6	22	17-1 to 17-6	3
14-7 to 15-0	33	17-7 to 18-0	3
15-1 to 15-6	28	18-1 to 18-6	2
15-7 to 16-0	19		
		Total....	136

5. Prepare the ruling for a chart like Figure 83, and insert the following cases in their correct positions:

C.A.	M.A.	C.A.	M.A.	C.A.	M.A.	C.A.	M.A.
8–2	9– 1	9–10	12–0	11–0	10–0	14–0	13–0
9–3	7– 0	10– 0	9–5	11–6	12–6	14–6	14–0
9–5	9– 5	10– 2	10–0	12–0	12–3	15–0	12–0
9–6	8– 0	10– 6	9–8	12–6	12–6	15–3	15–6
9–8	9–10	10– 8	10–6	13–0	13–5	16–0	12–0

6. Chart the age-grade distribution of Boise, according to *The Boise Survey*, page 130, following the individual distribution plan of Figure 83. It will be necessary to make the chart large, to allow room for all the dots. The largest number at any one intersection will be 74 (grade I–B, ages 6–6 to 6–11). Make sure, by pencil sketching, that there will be sufficient room for these before proceeding with the chart.
7. Following the general plan of Figure 85, with such modifications as may be necessary, chart the following data:

Intelligence Tests and Home Conditions

I.Q.	Inferior Home Boys	Inferior Home Girls	Average Home Boys	Average Home Girls	Superior Home Boys	Superior Home Girls
104	..	..	..	..	2	..
103	..	..	..	..	2	1
102	..	..	1	2	1	2
101	..	..	1	1	..	..
100	..	..	2	1	2	3
99	..	..	3	3	2	3
98	..	..	3	3	2	..
97	1	..	2	2	1	..
96	..	1	..	1	3	2
95	..	2	1	..	1	1
94	2	..	1	1	..	2
93	..	3	2	..	..	..
92	..	3	1	1	1	..
91	..	..	1	1	..	1
90	2	2	1	..	..	..
89	3	1	..	..	..	..
88	3	3	..	..	..	..
87	3	4	..	..	..	..
86	4	3	..	..	..	..
85	4	3	..	..	..	..

CHAPTER IX

BLOCK DIAGRAMS

(Explaining Figures 87 to 90, Inclusive)

General definition. Block diagrams are characterized by the use of areas whose essential feature is position, rather than size.

Curriculum charts. Figure 87 illustrates the use of the block diagram method of representing the entire course of study of a city school system. The subjects are shown at the left, listed in order of their occurrence as a pupil passes through the schools. To the right of each subject is an elongated space, stretching the length of the grade-range, as indicated by the horizontal scale at the bottom. The guide lines cut each subject-space into eight rectangles representing the eight grades. These rectangles are inked in, according to the grades in which the subject is taught. For example, in this city the subjects art, language, music, physical training, and physiology are taught in all grades; history-civics is taught in all but the latter half of the seventh; geography, from the fourth to the first half of the seventh; general science, in the eighth only.

The subjects taught in any grade may be seen quickly and accurately by glancing through the vertical columns representing the grade in question.

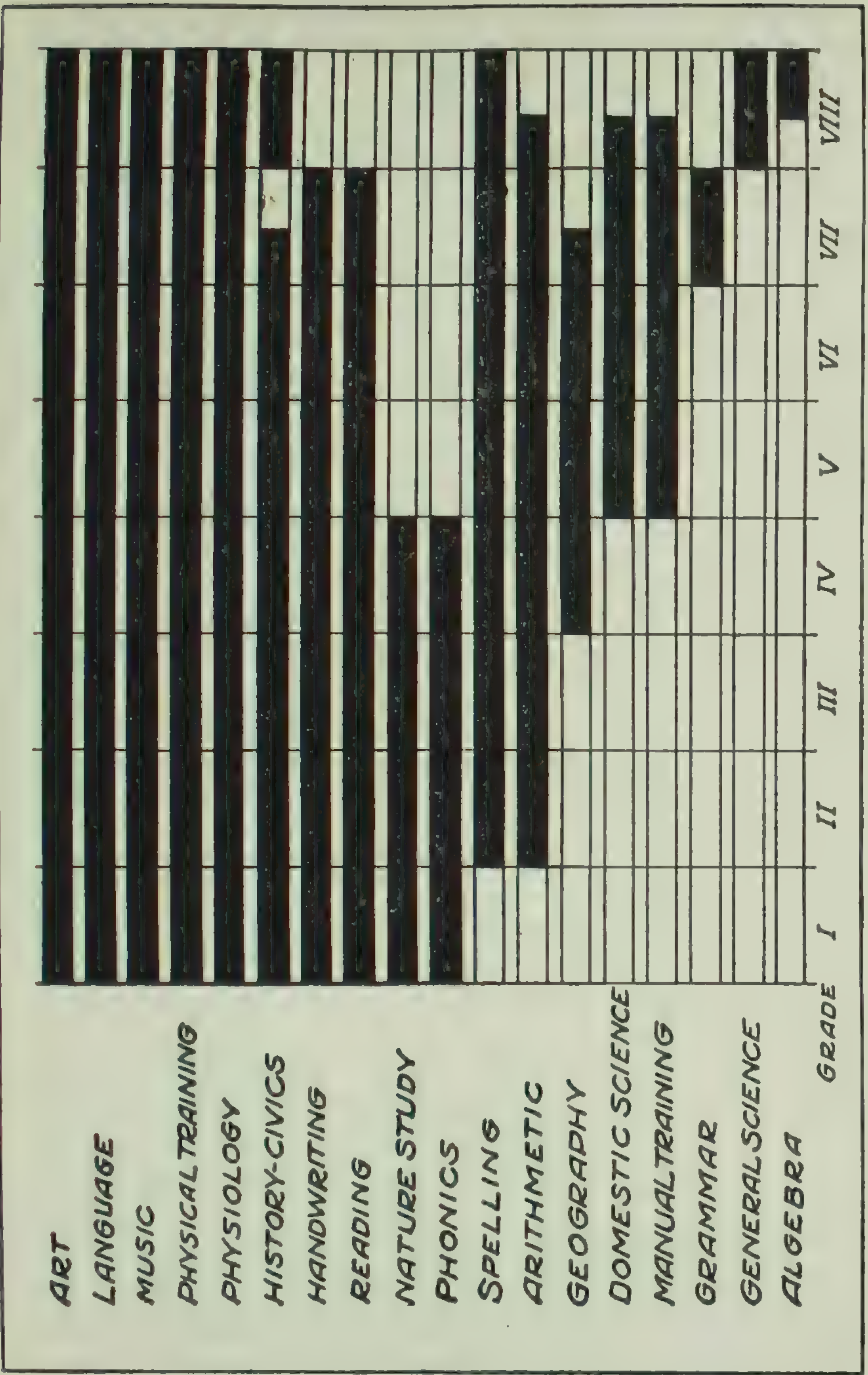


FIG. 87. COURSE OF STUDY FOR ELEMENTARY SCHOOLS OF BOISE, IDAHO
(From *The Boise Survey*, by J. B. Sears.)

Time charts. Figure 88 shows how a school principal used the block diagram method in scheduling his teachers for play-ground duty for one semester. The teachers' names are arranged alphabetically, at the left. Each week is shown by a rectangle, and the exact dates are numerically indicated at the bottom. It was necessary to have each teacher assigned two weeks of duty, and to see that each week was taken care of. It was not necessary, of course, that the assignment in each case should include two adjacent weeks, although this occurred for seven of the teachers. The purpose of the chart is to enable the principal and the teachers to see, at a glance, just who should be on duty at any given time.

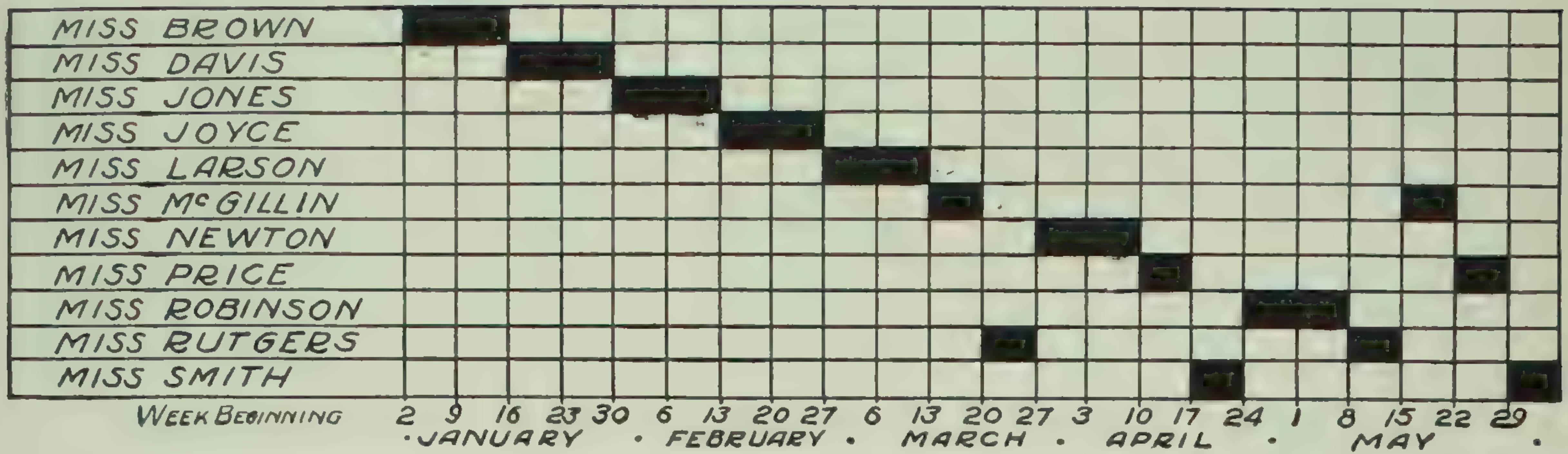


FIG. 88. WEEKLY ASSIGNMENTS OF TEACHERS TO PLAYGROUND DUTY IN A CITY SCHOOL
(After a chart in *The Principal and His School*, by E. P. Cubberley.)

Relative position blocks. The use of a "stack" of blocks, numbered in sequence, with one block especially designated, is illustrated in Figure 89. Here three facts are shown concerning the Boston public schools; namely, their position among 21 cities in: (1) expenditure for schools for each inhabitant; (2) expenditure per $1000 of taxable wealth; and (3) expenditure per child in average daily attendance. It will be seen that in items 1 and 3 Boston is nearly at the top of the list; in item 2, near the middle. In such a diagram it is important that the numbering begin at the top, so that the correct impression will be gained concerning relative position.

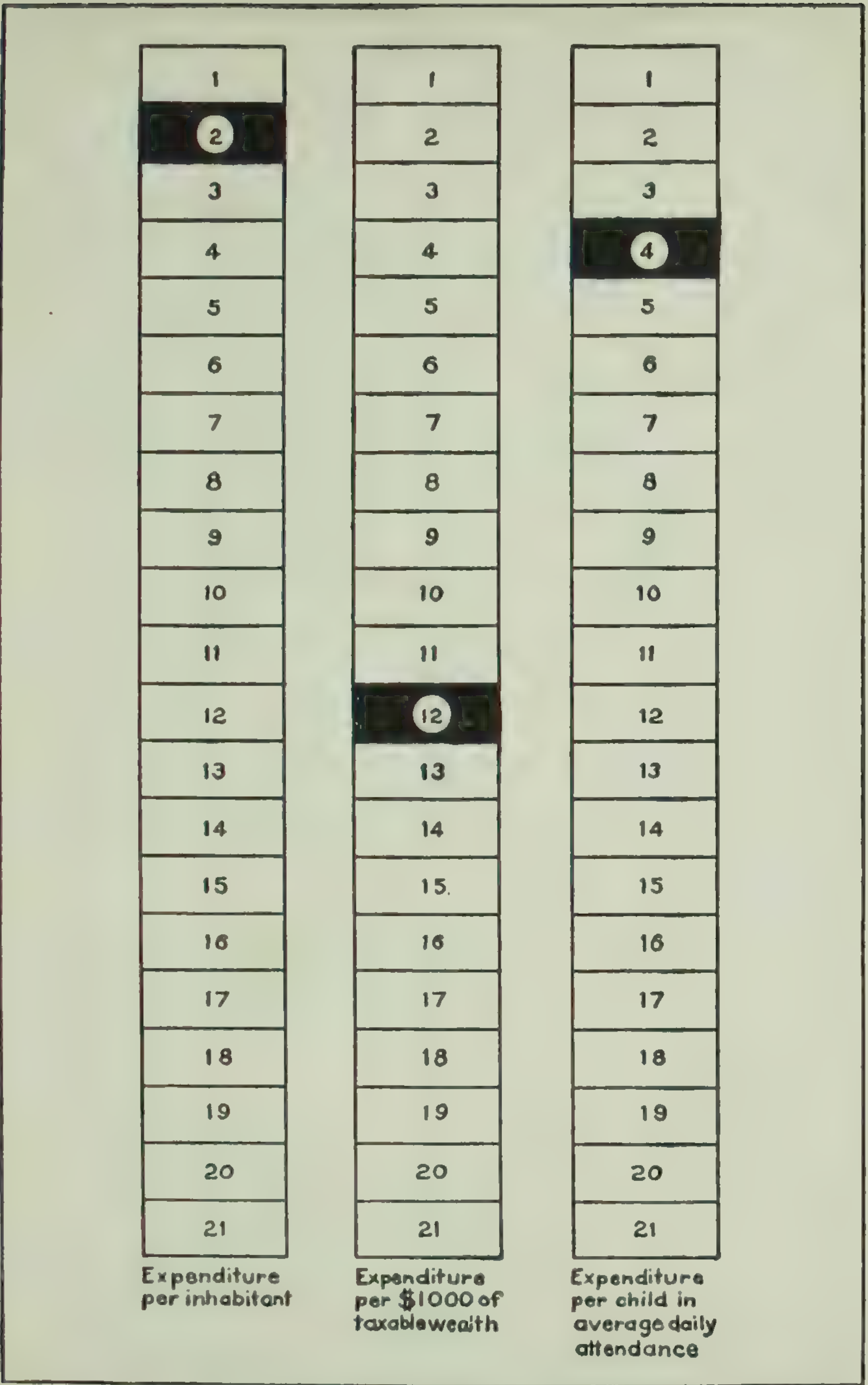


FIG. 89. RELATIVE STANDING OF BOSTON AMONG 21 CITIES IN SCHOOL EXPENDITURES

(From *Boston School Report*, for 1916.)

Comparative relative position blocks. In Figure 90 the use of relative position blocks for comparative series is illustrated. The relative standing of a number of schools is shown in each of five school subjects — arithmetic, reading, spelling, language, and handwriting. The blocks are numbered from the top down, according to the number of schools. The order in which the schools are listed is the order of standing in arithmetic. The relative standing in the other subjects is then shown by drawing a heavy line for each school, connecting the blocks representing its rank order. Thus the Wilson School, in arithmetic ranks 8; in reading, 4; in spelling, 5; in language, 6; and in handwriting, 7. The Jackson School ranks 12 in all subjects excepting language, in which it ranks 11. Note that there is a general correspondence of rankings for a given school, but that some striking individual differences occur. The superiority of the graphic, over the numerical method of showing these facts, will be evident.

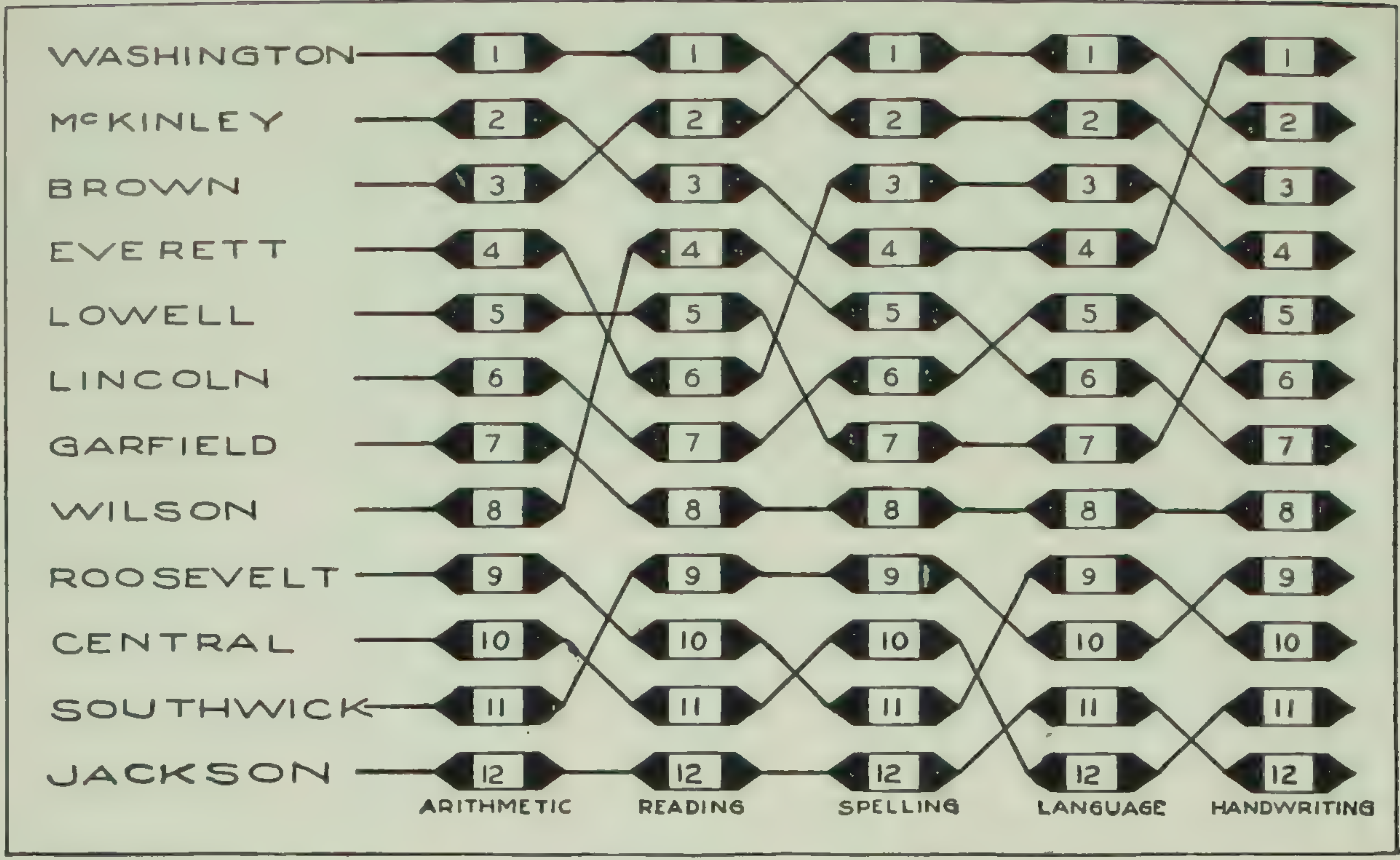


FIG. 90. RANKING OF A GROUP OF ELEMENTARY CITY SCHOOLS, ACCORDING TO THEIR MEDIAN SCORES IN FIVE ACHIEVEMENT TESTS

PROBLEMS FOR CHARTING

1. Chart the curriculum of the elementary schools of your own or some other city, according to the plan of Figure 87. The data may be found in the course of study issued by the superintendent of schools.
2. Work out a plan for assigning pupils to schoolroom tasks or schoolyard duties, patterned after Figure 88.
3. Following the relative position method illustrated in Figure 89, show the relative position of your State among the States of the Union in the following items: population; wealth; value of farm products; and expenditure for education.
4. Chart the following data following the plan of Figure 90:

RELATIVE STANDING, BY TESTS, OF THE GRADES OF THE ROOSEVELT SCHOOL ACCORDING TO GRADE-NORMS IN FOUR SCHOOL SUBJECTS

	ARITHMETIC	READING	SPELLING	HANDWRITING
Grade III	2	1	3	2
Grade IV	1	2	2	1
Grade V	4	4	1	4
Grade VI	3	5	6	5
Grade VII	5	3	5	6
Grade VIII	6	6	4	3

5. Show the changes in population rank of the States of the Union according to the Census data for 1880, 1890, 1900, 1910, and 1920, following the method illustrated in Figure 90. There will be five columns of blocks. The first column will represent the year 1880, in which the ranking will be in consecutive order, from 1 downward. By tracing the connecting lines it should be possible to observe the changes for each State, with special reference to significant rise or fall in rank.

CHAPTER X

ORGANIZATION CHARTS

(Explaining Figures 91 to 98, Inclusive)

General definition. An organization chart is a diagrammatic representation of an enterprise, or project, in which a number of persons occupy positions of varying responsibility or rank. There is usually an executive head, or governing body, which is responsible for the direction of the organization. Under the executive head are all of the employees, each working under a responsible superior officer. Large business concerns and railroad companies are frequently organized so efficiently that such a diagram can easily be constructed from an outline of their daily business routine. In some cases organizations are planned graphically, and operated in accordance with such representation. Military organizations have long since seen the necessity for defining responsibilities. In general, it may be said that the efficiency of an organization can be measured by the ease with which it may be charted. A loosely organized business, in which employees are uncertain to whom they are responsible, and sub-officials are equally uncertain as to their duties and responsibilities, can be shown by the chart method how to function better.

Public school systems and other educational enterprises are governed by the same laws of efficiency which characterize business organizations. School surveys have shown that the failure to follow a sound plan of administration often results in waste and inefficiency. These surveys have shown, through organization charts, what the local difficulties are, and how they may be overcome.

Organization charts must be based on accurate and complete knowledge of the problem, with special reference to adjustment to local conditions. Most school systems can easily improve their organization; and the best beginning is to chart the existing plan, and to aim toward its simplification.

Departmental organization. The direct system of administration and responsibility has been developed to a high degree by railroads. Figure 91 shows the organization of one of the many departments of a large railroad. The department is under the complete direction of the traffic manager, in whom is vested sufficient authority for the carrying out of his responsibilities. He, of course, is responsible to a superior officer, who is not represented on this chart, because the department operates as a complete unit of the company's activities, and its proper location in the general plan of organization is assumed. Under the traffic manager are two divisions — passenger service and freight service, each under a sub-manager. Under these, and in the line of direct authority, are the agents, each assigned to a specific type of responsibility.

The simplicity of this chart is the index of the efficiency of the organization which it represents. The traffic manager, although vested with complete authority, does not deal directly with local and district agents, but can be reached only through his two chief sub-managers, whose duty it is to keep him properly informed concerning the details of their respective divisions.

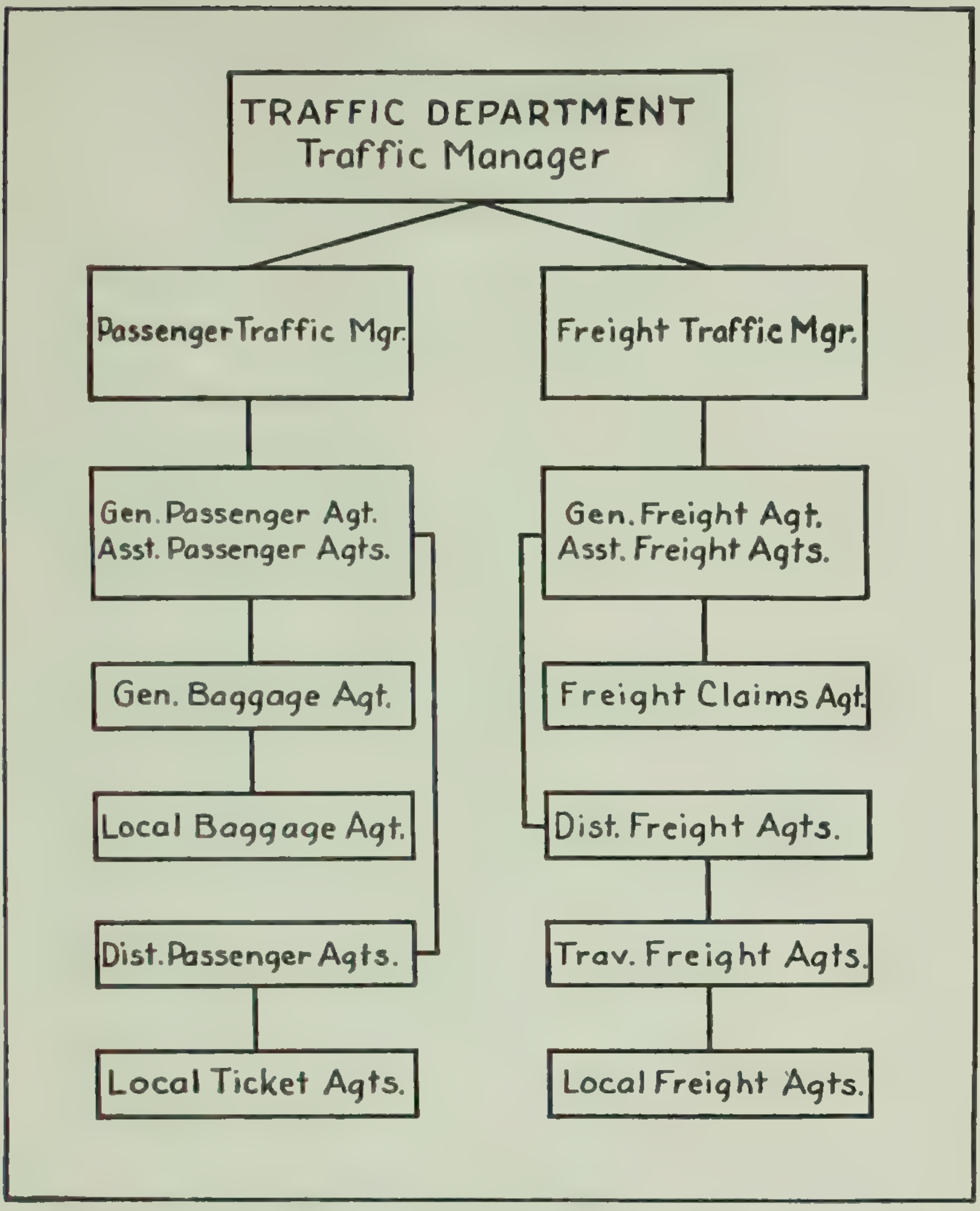


FIG. 91. ORGANIZATION OF A RAILROAD TRAFFIC DEPARTMENT
(From *Occupations*, by Gowin and Wheatley.)

State and county educational organization. In recent years much attention has been given to the improvement of the public schools through better planning of administrative organizations. The significance of the State-control movement in education and its importance is emphasized by Professor Cubberley in *The History of Education.* He says:

> The different national school systems . . . represent a great world movement which characterized the latter half of the nineteenth century. The movement is still under way, and is increasing in strength. Beginning with the nations which were earliest to the front of the onward march of civilization, the movement for the state control of education, itself an expression of new world forces and new national needs, has in a century spread to every continent on the globe. To-day progressive nations everywhere conceive of education for their people as so closely associated with their social, political, and industrial progress, and their national welfare and prosperity, that the control of education has come to be regarded as an indispensable function of the State.

The practical working-out of the functions of the State has produced, during recent years, a number of administrative plans. Although these differ according to local conditions, the principles of uniformity, simplicity and direct responsibility characterize all suggested plans. Figure 92 shows a proposed educational organization of a single county, conceived as a unit in the State educational department. Through the center runs the line of direct responsibility, the superintendent of schools being the chief executive officer. The dotted line dropped from the State Board of Education and the County Board of Education indicates that the authority is direct, but not of equal intensity with the local authority.

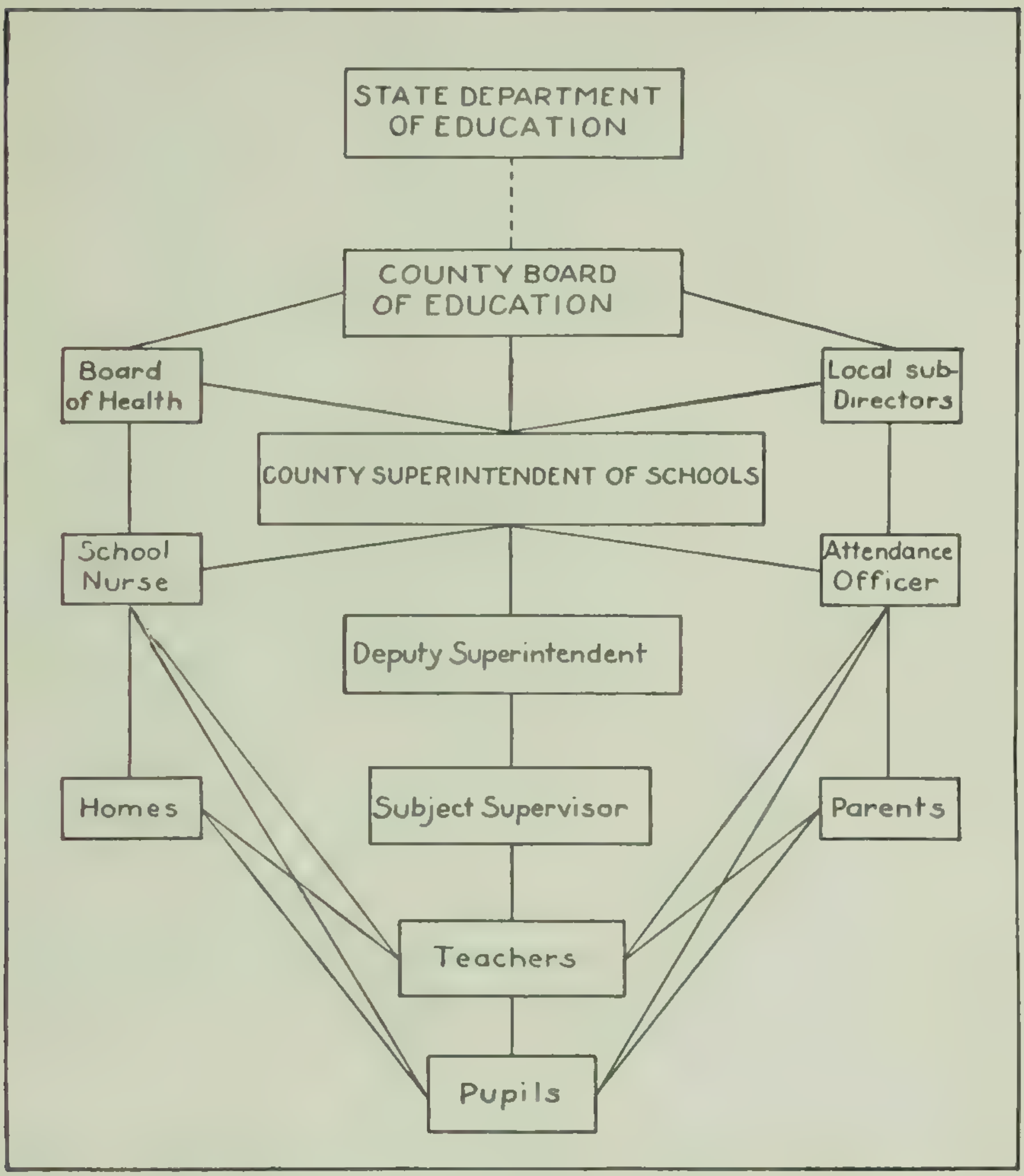


FIG. 92. PROPOSED PLAN FOR THE ORGANIZATION OF A COUNTY EDUCATIONAL SYSTEM

(From *The American Public School*, by R. L. Finney.)

City educational organization. Figure 93 shows a proposed organization for the city schools of Boise, Idaho. In the report of the school survey in which this chart was used the importance of improving the administrative organization was set forth as one of the most effective ways to bring about increased efficiency in all departments. The plan shown in Figure 93 was preceded by a chart showing the organization which the survey staff found in operation. Its inefficiency and inadequacy, in comparison with the proposed plan, were clearly brought out by the relative simplicity of the latter diagram. The comparison brought out how the superintendent, as the responsible head of the school system, could be given authority commensurate with his duties; how the board of education could more effectively carry out their functions by vesting more direct authority in the superintendent, and holding him responsible for results; and how the same sort of procedure between the superintendent and principals, and supervisors and teachers, could be put into effect. These improvements were brought out so forcefully through the chart method that their significance would be obvious to persons knowing little or nothing about the technique of school organization; and yet they served as a technical basis for the working out of the improved organization.

Regarding the proposed plan Professor Sears, director of the Boise survey, wrote:

> This plan calls for several marked changes in the present practice. It is believed to embody the best principles of organization and administration and at no point to conflict with what has been found successful expression in practice.

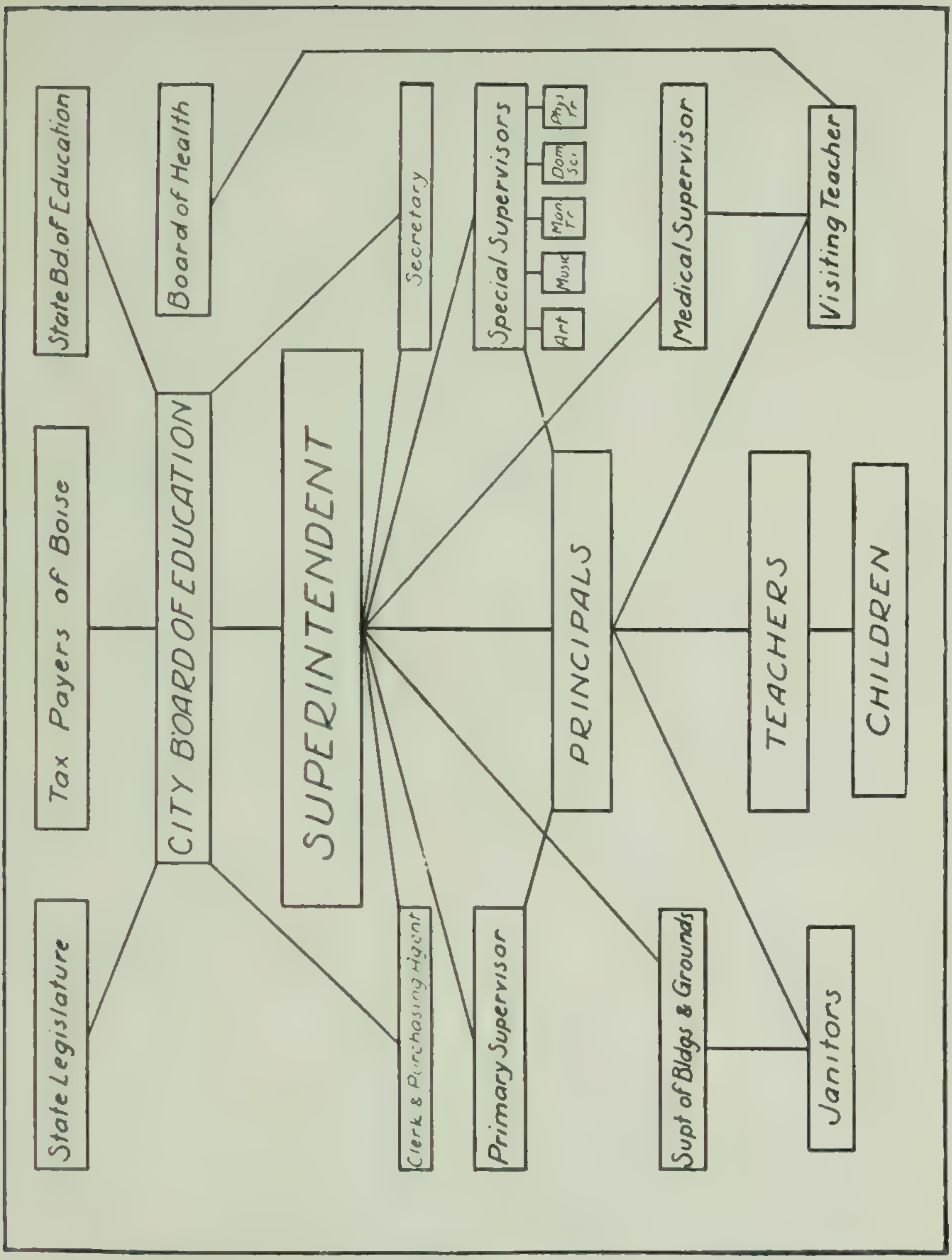


FIG. 93. PROPOSED ADMINISTRATIVE REORGANIZATION OF THE PUBLIC SCHOOL SYSTEM OF BOISE, IDAHO

(From *The Boise Survey*, by J. B. Sears.)

State health organization. The organization of health work has also become an important function of the State, and is closely allied to the administration of public education. Its effectiveness depends largely upon the establishment of direct lines of authority and responsibility. It is important that each officer and employee shall be assigned definite duties, and maintain definite relationships to his associates. These can be clearly shown by means of blocks and lines.

Figure 94 is the organization chart of a bureau of one of the most efficient State health departments. The chief executive officer of the entire department is the State Commissioner of Health, to whom all bureau directors are responsible. The work of this bureau, as shown in the chart, is divided into four functions: service, coöperation, administration, and organization. Each division has a number of sub-departments, each of which is represented. The chart shows not only specific positions, but also the functions which the bureau performs.

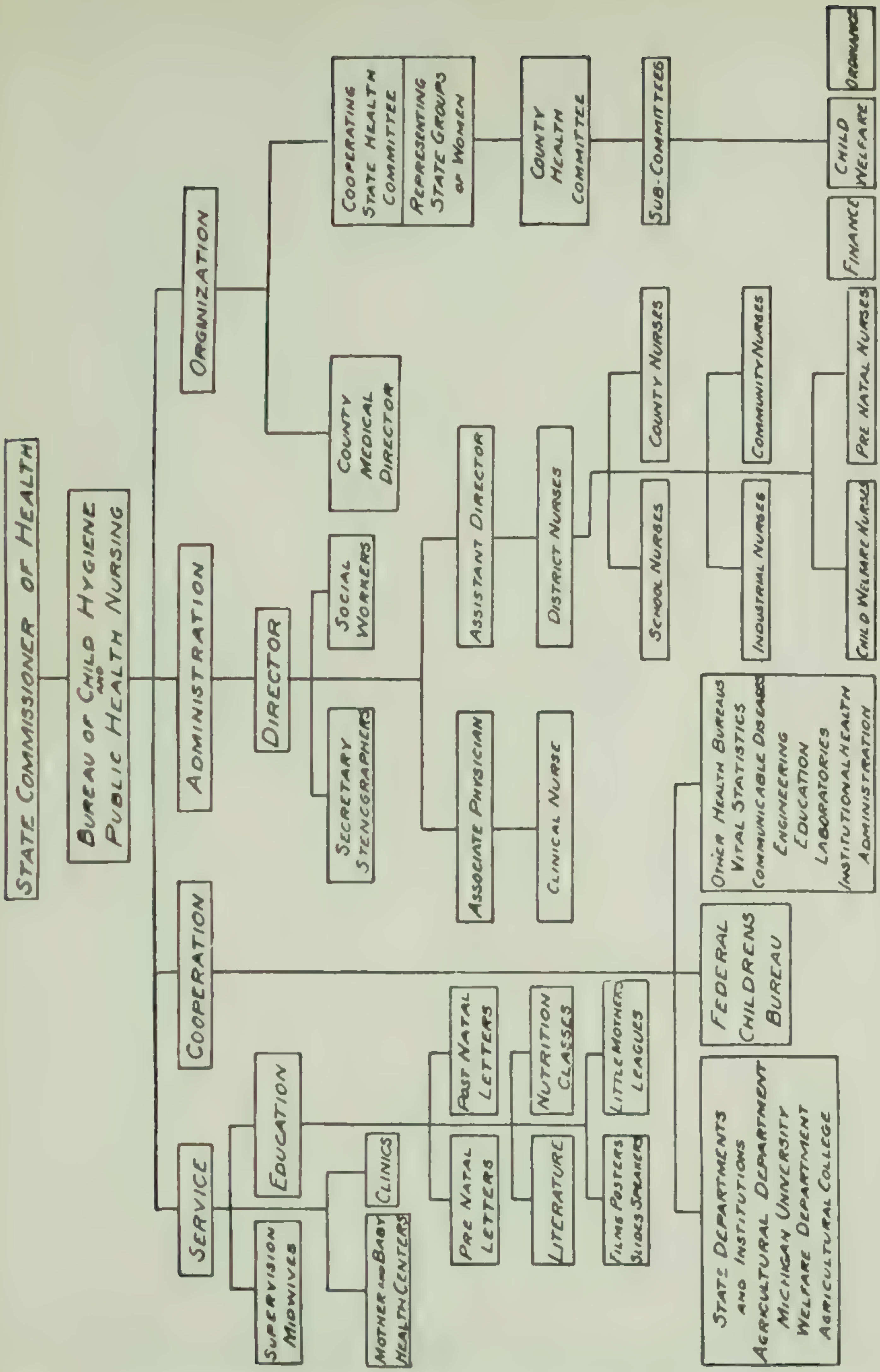


FIG. 94. ORGANIZATION OF THE BUREAU OF CHILD HYGIENE AND PUBLIC HEALTH NURSING OF THE MICHIGAN STATE DEPARTMENT OF HEALTH

(From *Public Health*, issued by the Michigan State Department of Health July–August, 1922.)

Coöperative organizations. Figure 95 shows a proposed plan for a community psychiatric clinic. This is not a single organization, as in the case of the railroad, the schools, and the health departments shown in the preceding charts, but represents an affiliation of organizations for a specific purpose. The central organization is shown in the center, in a heavy block. The principal supporting groups and methods of gaining support are shown above and at either side. Below are shown the institutions and social agencies in which the clinic is to operate. The use of the dotted lines indicates that the responsibility and authority are not direct, as in single organizations, but that the proposed enterprise is to be held together through the coöperation and moral support of the agencies concerned.

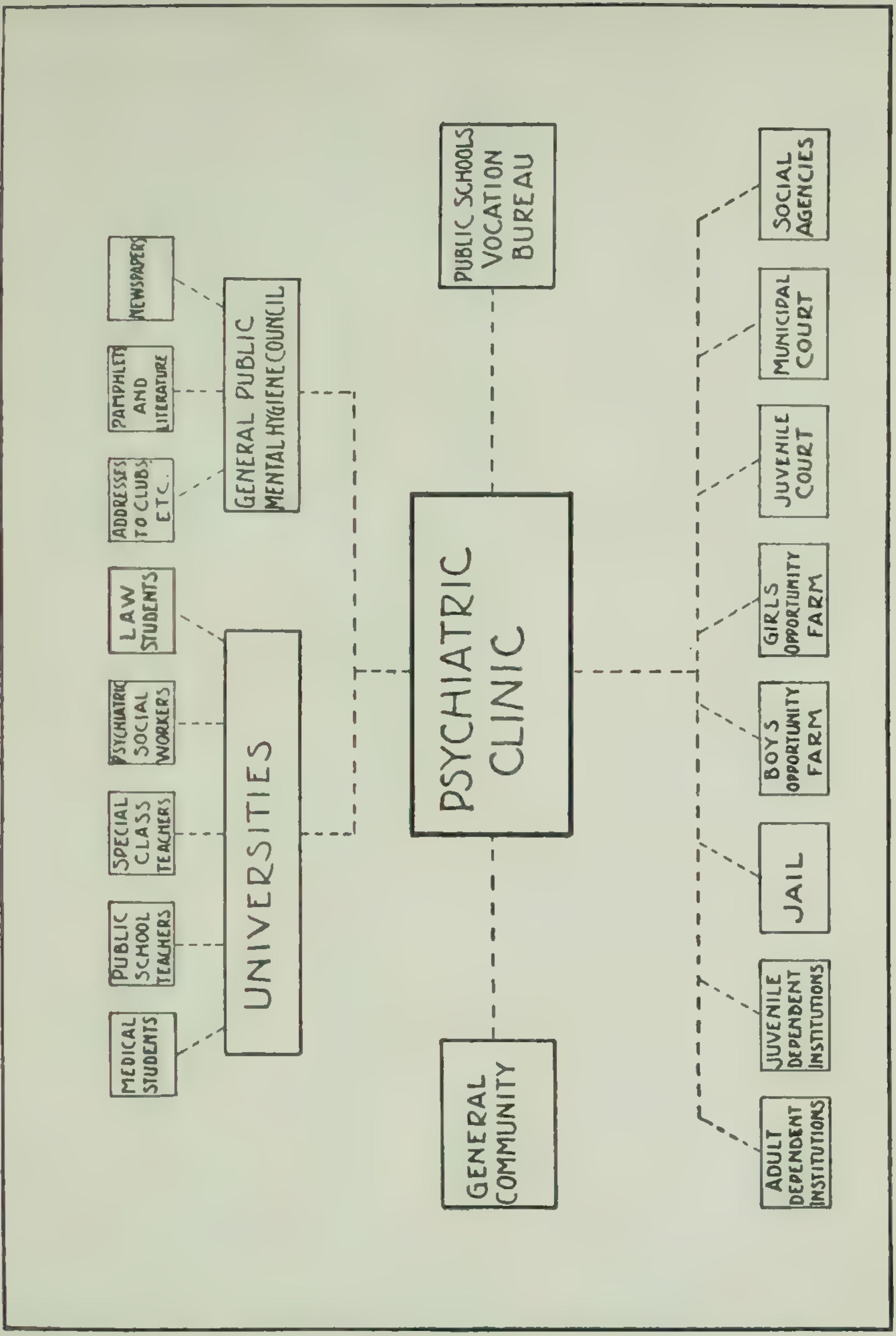


FIG. 95. PROPOSED ORGANIZATION OF A COMMUNITY PSYCHIATRIC CLINIC

(From *Mental Hygiene Survey of Cincinnati.*)

Structural organization charts. The structure of the educational system of England is shown in Figure 96. In this case the types of schools are represented by rectangles, lengthened in each case according to the number of years required for the completion of each unit. Beginning with the kindergarten, or early infant school, at the ages of three or four years, the child proceeds to the higher infant school. At the age of eight or nine he may continue in the regular elementary school, or enter the preparatory school. The system branches out somewhat like a tree, indicating the importance of each student's choosing the branches which will best fit him for his career. The single-hatched areas indicate the elementary and secondary school courses, extending from five to nineteen years.

This is one of a series of excellent diagrams in Professor Cubberley's *History of Education*, in which the school organization plans of several countries are shown.

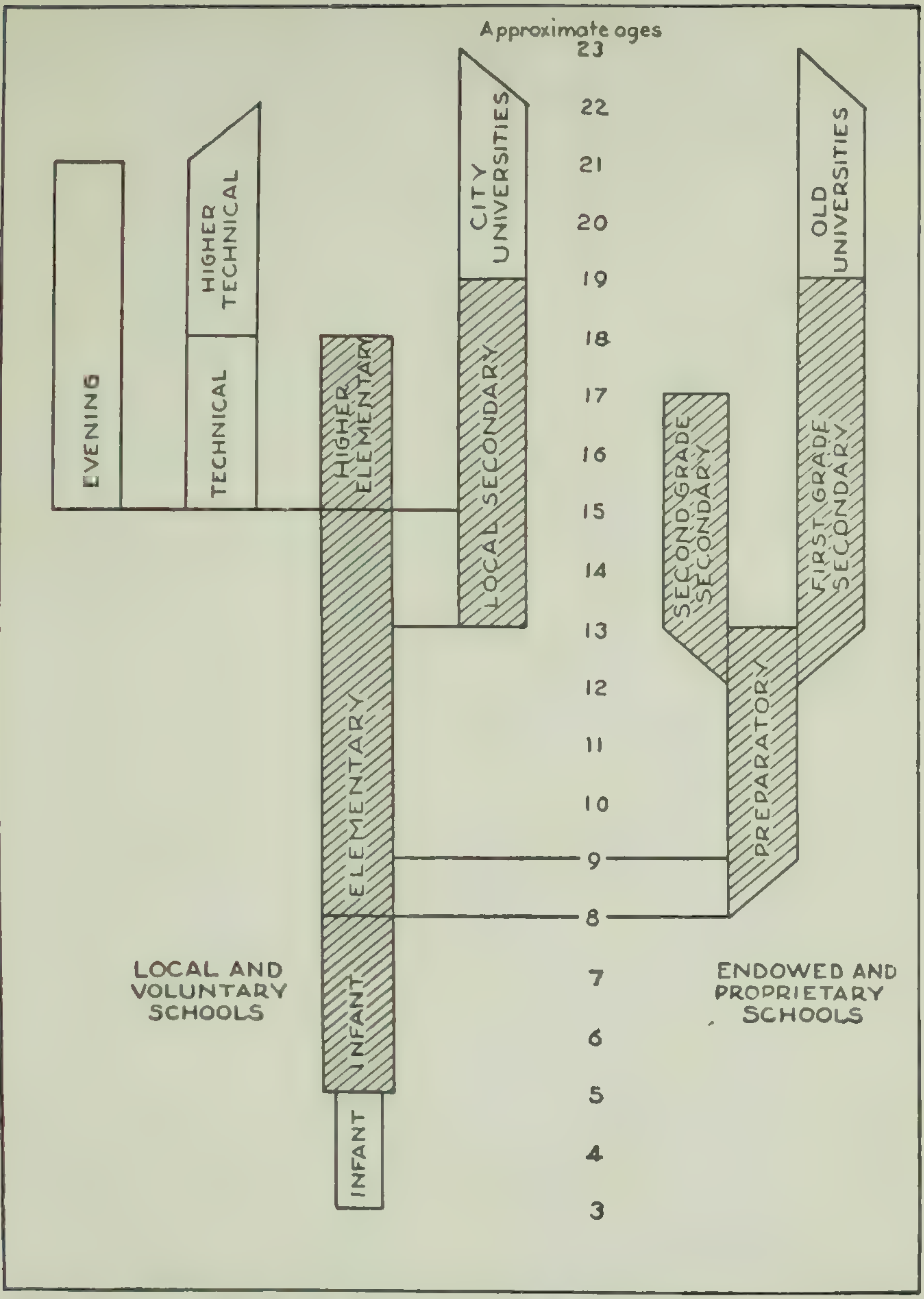


FIG. 96. DIAGRAM OF THE ORGANIZATION OF THE EDUCATIONAL SYSTEM OF ENGLAND

(From *The History of Education*, by E. P. Cubberley.)

Schematic organizations charts. Figure 97 illustrates the use of the diagrammatic method to show clumsiness or unwieldiness of functioning, contrasted with the efficient operation of a simpler plan. In the diagram, at the left, representing "the schools as they are," the central feature is the board of education of fourteen members, with a large number of unnecessary committees, endeavoring to carry on the executive work of the school system. The bulging out of the system at its center gives a correct impression of what actually happens when organizations are allowed to develop in such a way.

At the right is shown the desirable form of administration. The board has but five members, elected in the same manner as the previous board, but whose chief function is the selection of an executive officer, the superintendent of schools, in whom all educational functions are vested. The diagram of the proposed organization is in accord with the leading views concerning the administration of public education.

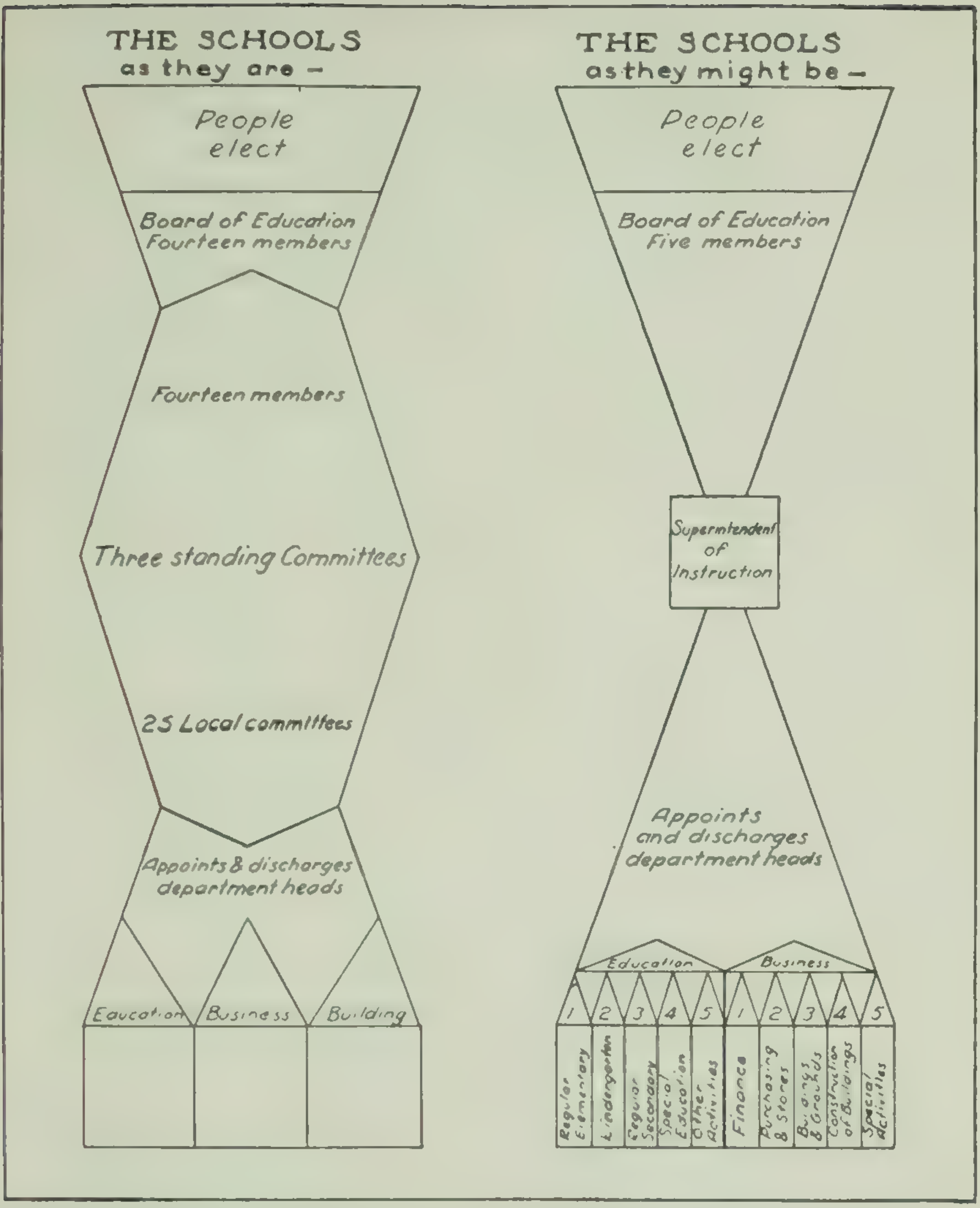


FIG. 97. DIAGRAM OF THE EXISTING AND PROPOSED ADMINISTRATIVE ORGANIZATION OF THE PUBLIC SCHOOLS OF DAYTON, OHIO

(From *Report of Dayton Bureau of Research*, 1917.)

Circular organization charts. Frequently it is desired to represent organization responsibility by means of circles and radiating lines. An example of this form is shown in Figure 98. The principal feature of the chart is the emphasis placed on the authority of the superintendent of the prison, to whom each department head, with a few exceptions, is directly responsible. The assistant superintendent does not act in the capacity indicated by his title, but is in direct authority over five especially designated departments. The matron is in complete jurisdiction over the women's department, and is directly responsible to the superintendent. Note the use of additional blocks with numerals to indicate the number of inmates assigned to each department. The construction engineer, shown in the lower left-hand portion of the chart, is not completely under the jurisdiction of the superintendent, which fact is indicated by the dash line connecting the respective circles.

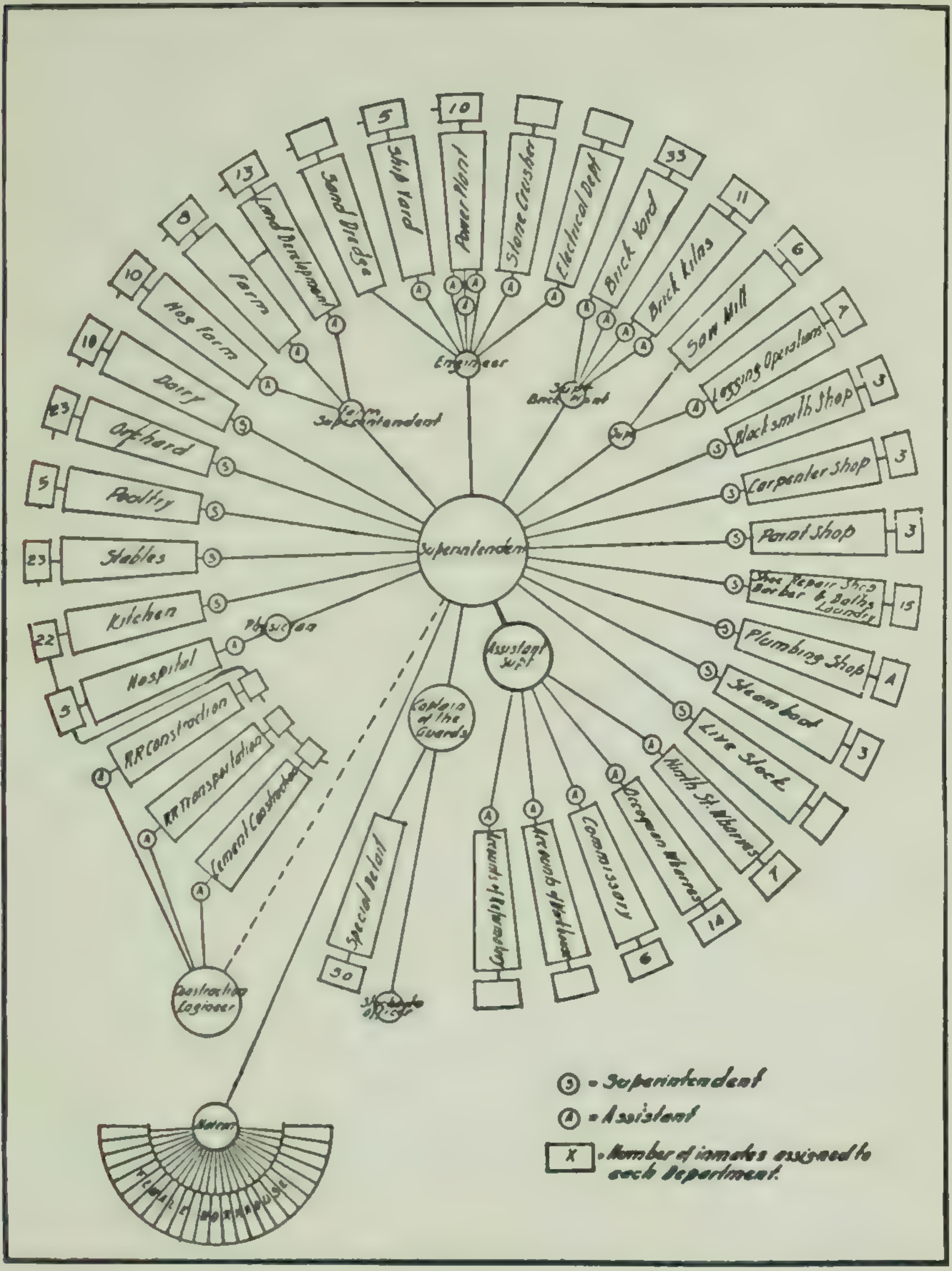


Fig. 98. Plan of Administration of a Workhouse
(From *The Survey*, August 16, 1920.)

PROBLEMS FOR CHARTING

1. Redraw Figure 91, widening the chart to show the district passenger agents and district freight agents in line of direct responsibility, without the use of the outside connecting line. This will necessitate four columns of blocks instead of two.
2. Chart the organization of your own city system of public schools, following the general plan of Figure 93. Each city has some special type of activity or authority by which it may be characterized.
3. Obtain data concerning one of the governmental departments in your State and chart it, following the plan of Figure 94.
4. Following the plan of Figure 96, redraft a diagram of a foreign school system, choosing from the following, in Cubberley's *History of Education:*

Prussia	page 577
France	598
Italy	610
Denmark	713
Argentine Republic	718
Japan	720
China	721
Philippine Islands	740

5. Chart the data of Figure 97 or 98 according to the block-diagram method.
6. Make an organization diagram of the data shown in *Then and Now in Education*, by Caldwell and Courtis, Figures 4 and 5. Let the diagram be comparative, so that the practical differences in the school organization of Boston in 1845 and Detroit in 1921 will be brought out. Note particularly the facilitating and coöperating agencies. The purpose of the chart will be to show *improvement*. Let this fact be made evident in the diagram.

CHAPTER XI

MAPS

(Explaining Figures 99 to 109, Inclusive)

General definition. Chart or diagrammatic maps differ from geographical maps in that the essential purpose of the former is to bring out special facts. Often the strictly geographical features of maps are omitted for chart purposes. In other cases the accuracy of the map is of so little importance that an exact reproduction is not necessary. It is important, however, that care be taken to represent the data truthfully, and to avoid distortion or changes which would tend to mislead the reader. Maps drawn with States out of their correct positions or distorted in proportions are not truthful, and have no real advantage over correctly drawn charts.

Most persons are interested in maps, and to many they have a special appeal which makes this method of presentation especially useful. With increased knowledge of geography on the part of the general public, maps and map charts will probably come into extensive use. Many recent educational texts contain such charts. In recent years maps have been used to good advantage in advertising.

This chapter illustrates a few of the more common methods of map representation, selected with special reference to simplicity of structure and freedom from unnecessary detail.

District-line maps. Figure 99 is a simple map, of a type which need not be drawn to exact scale. Its purpose is to show how a slight modification of district lines permits a better distribution of attendance in several adjacent schools. Six districts are shown, each bounded by a solid line. The problem of distribution particularly affects District C. At the present time there are 44 pupils enrolled, each shown by a dot. The location of each dot shows the approximate location of the pupil's residence with reference to the school. It is proposed to move the district lines in four places, so that two of the pupils will go to District B, five to District D, and four to District F. At the same time District C will receive seven pupils from District B and six from District E. The arrows indicate the direction of the transfer. The new pupils to enter District C are shown by crosses, to distinguish them from those who are now in attendance.

The chart is simply drawn, but it clearly brings out the point it is intended to convey; namely, the practical advantage of the slight change in district lines.

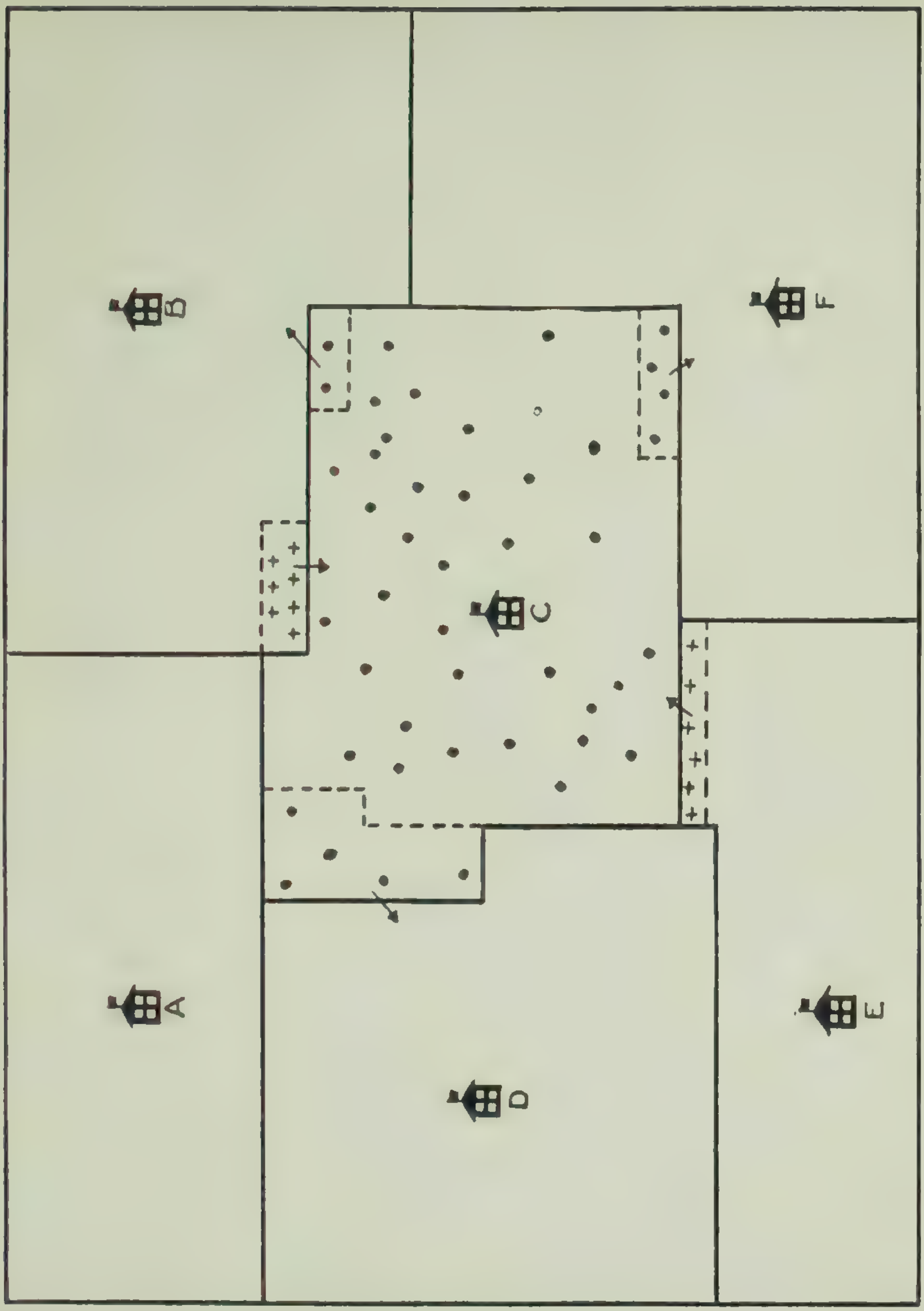


Fig. 99. School District Sketch Map, Showing Plan for Relieving Congestion by Slight Changing of District Lines

(From *The Principal and His School*, by E. P. Cubberley.)

Special location maps. Figure 100 illustrates a type of chart map often used to designate the location of a building. In this case the location of a high school is shown. A section of the city is represented, showing several blocks comprising the immediate neighborhood, with special emphasis on certain public buildings and a park, so that the relative position of the school may be fixed in the reader's mind. The school is shown in solid black, to make it the most prominent feature of the chart. The other buildings and the park are shown as single-hatched areas. The arrow pointing to the school adds emphasis. Note that the names of all the streets are plainly shown. Even a stranger in the city would have little difficulty locating a building from such explicit graphic directions. In reduced form, chart maps of this kind can be printed on announcements of meetings. Their more extensive use would facilitate the work of conventions and teachers' institutes.

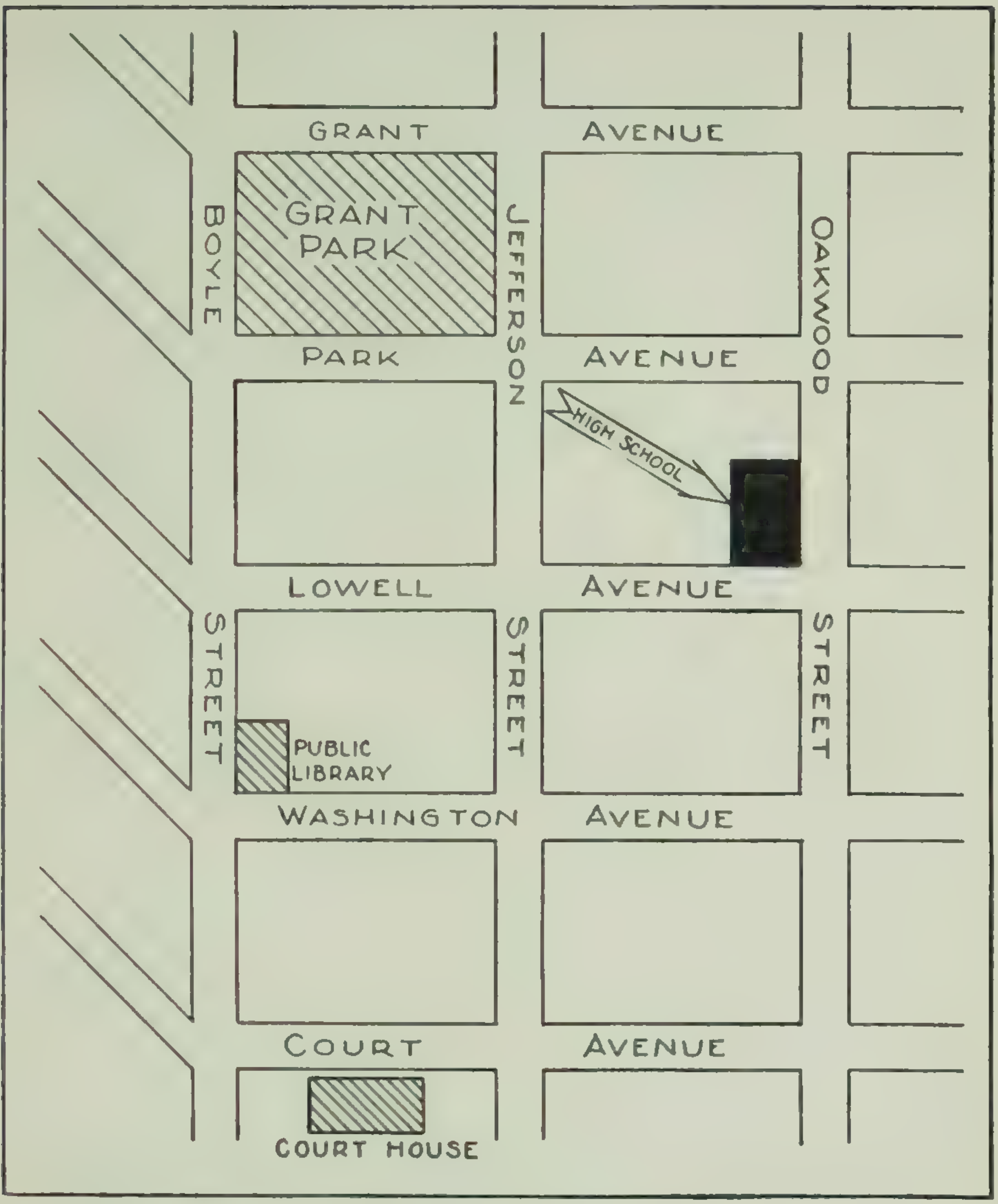


Fig. 100. Section Map, Showing Location of a School

Service-area maps. Figure 101 also shows a section of a city and the location of four high schools. In this case the exact location is not stressed, so that the names of the streets and the location of landmarks are not given. Only a few of the main streets or avenues are shown. The purpose is to show the probable service area, or drawing territory, of a proposed new high school, in relation to the areas served by three existing schools. The schools are enclosed in circles of equal size, drawn with a fixed radius, as a mile or a mile and a half, that for the proposed school being drawn heavier for emphasis. This sort of graphic information is useful and effective in acquainting communities with their educational problems and the service rendered by the schools. In bond issue campaigns such charts mean more, and will be remembered better by the average reader, than will purely verbal or statistical statements.

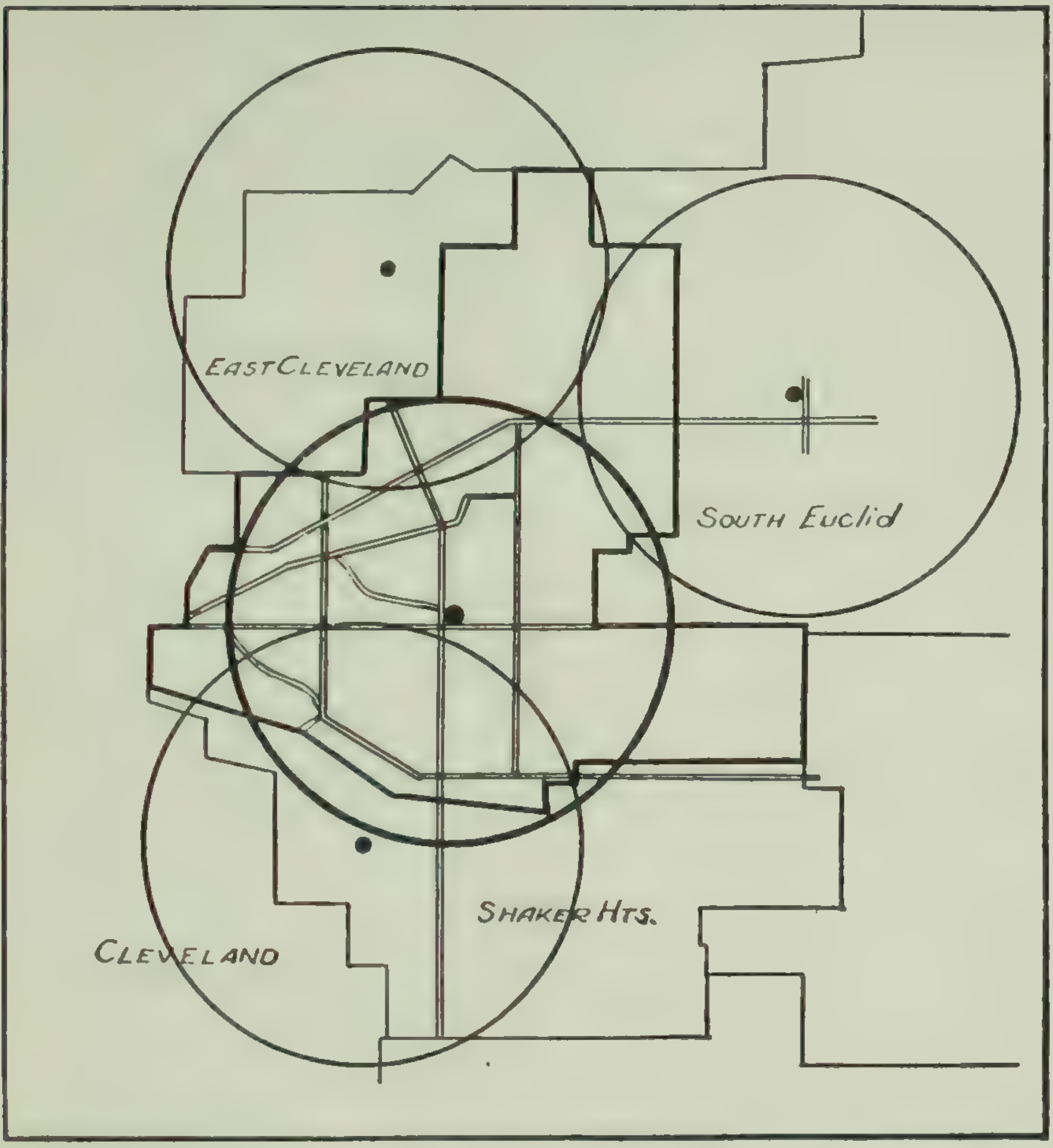


FIG. 101. MAP SHOWING PROPOSED LOCATION OF A NEW HIGH SCHOOL AND ITS DRAWING TERRITORY, IN RELATION TO OTHER HIGH SCHOOLS
(From *School Building Survey of Cleveland Heights, Ohio.*)

Diagrammatic maps. Figure 102 tells the story of an epidemic of scarlet fever which broke out in Norwalk, Connecticut, in 1897. Investigation by the health authorities revealed that practically all of the cases were on the route of a certain milk-distributing agency (H), and from this point the epidemic was traced to its source — a single case of scarlet fever in the home of a dairyman (K), one of three who supplied milk to the agency in question. The milk route which it is desired to emphasize is shown by a dash line; as is also the connection between K and H. Each home having cases of scarlet fever is shown by a dot, placed approximately in its location. The consistent adherence of the cases to the affected milk route, while the routes of other milk distributors remained free, with the exception of two sporadic cases on route J, is plainly brought out.

This chart is used effectively by Professor McCarthy in an excellent school text in the field of civics and health.

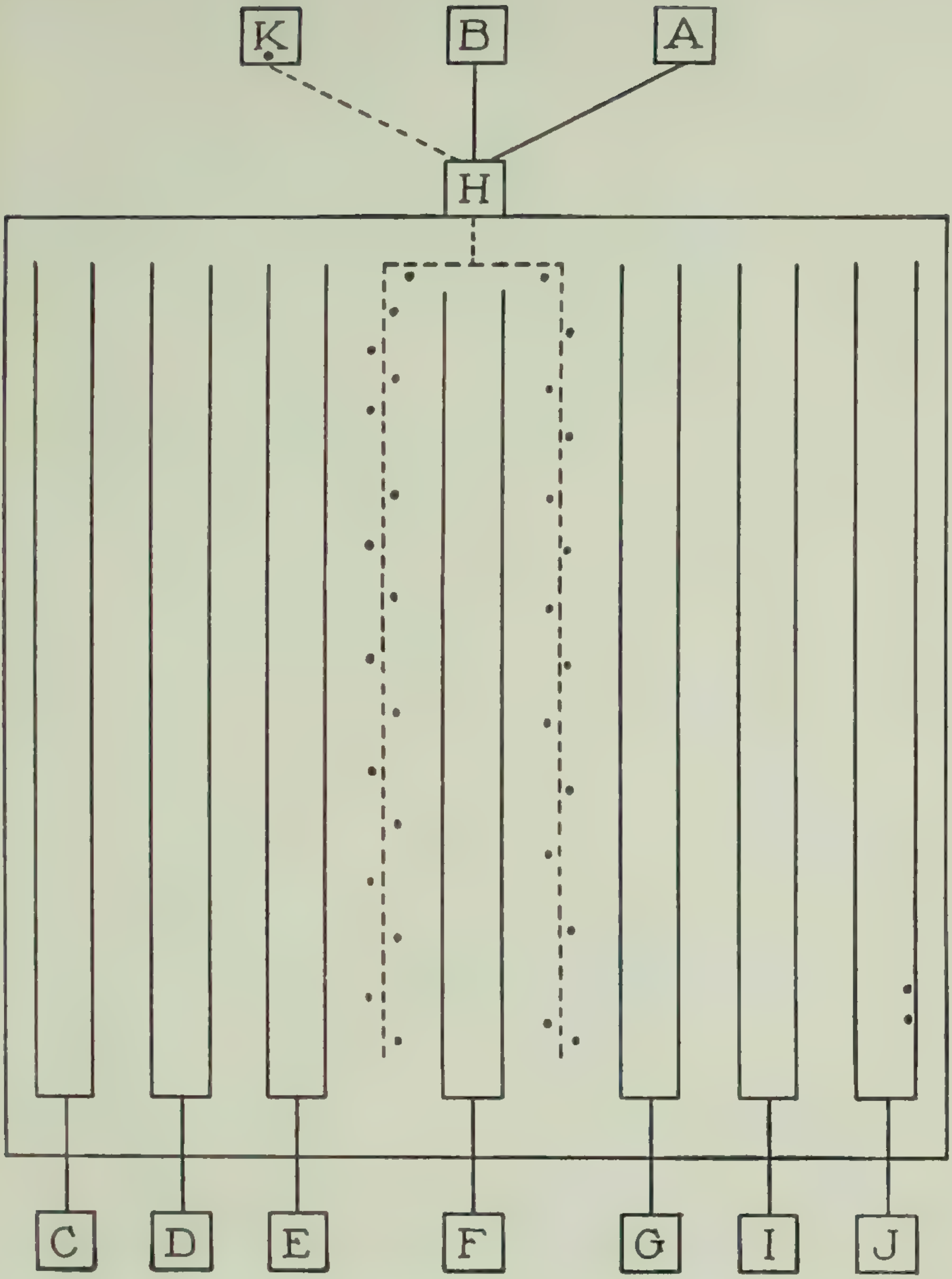


FIG. 102. DIAGRAMMATIC MAP SHOWING THE RELATION OF MILK ROUTES TO AN EPIDEMIC OF SCARLET FEVER IN NORWALK, CONNECTICUT, IN 1897

(From *Health and Efficiency*, by J. D. McCarthy.)

Outline-map designation. Figure 103 is an outline map of California, on which are designated, by name and location, a group of cities and institutions in which a certain welfare organization is operating. An agent of the organization visits each of these "social sub-stations" periodically, and efforts are made to extend the work geographically. The map appeared in an annual report setting forth the scope of the organization's activities. The efficiency of the work is emphasized by the chart, for persons familiar with charitable work in California will recognize immediately that practically every important institution and social service center is reached by this service.

The type of local activity (S.C. or C.C.) is indicated, and the larger cities are shown by heavy lettering. The State institutions are numbered, so they may be referred to in the comparisons which occur in the verbal report.

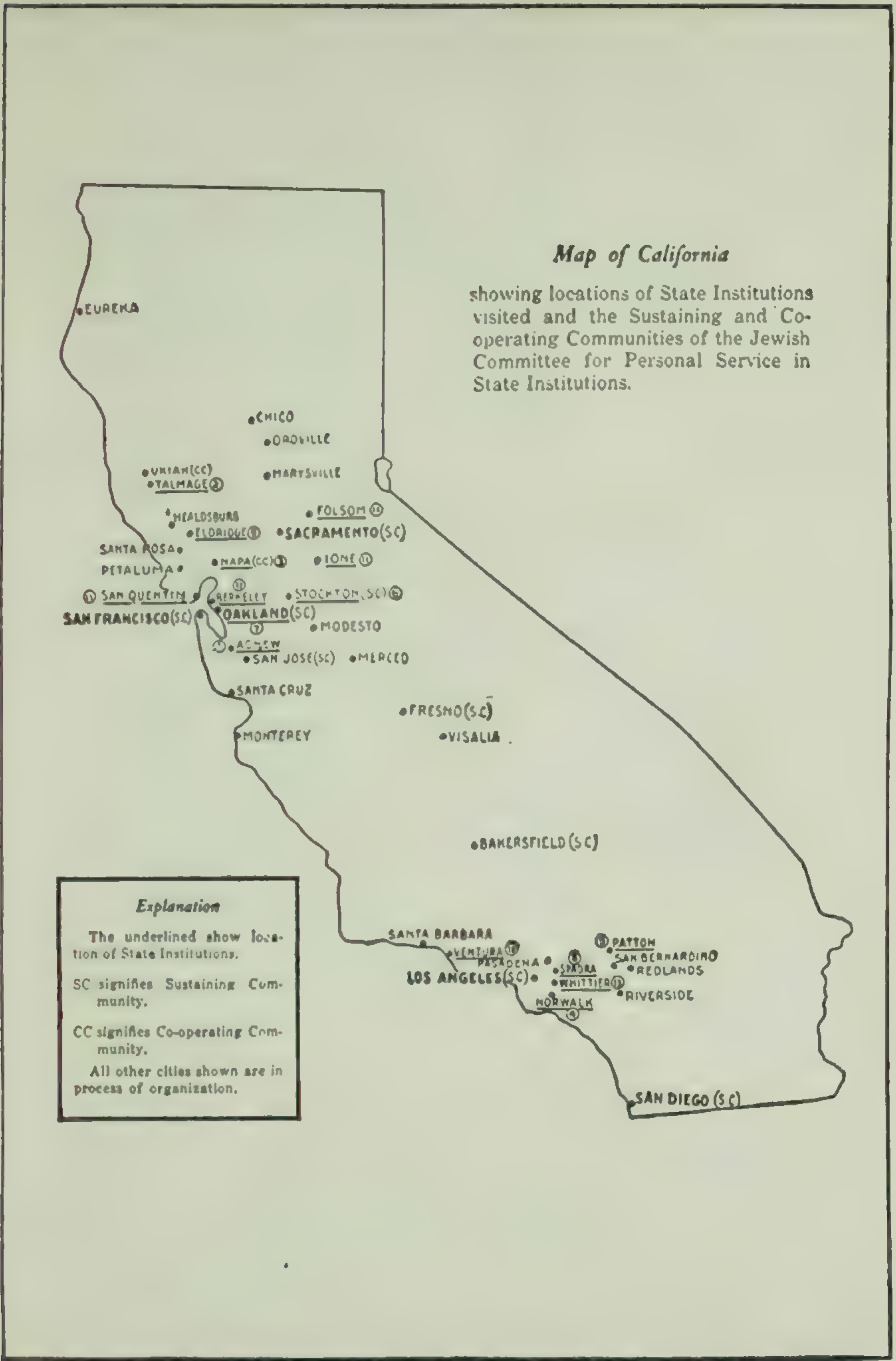


FIG. 103. MAP OF CALIFORNIA, SHOWING SCOPE OF WORK OF JEWISH CHARITABLE WORK IN INSTITUTIONS

(From *First Annual Report of Jewish Committee for Personal Service in California State Institutions*, by W. R. Blumenthal.)

Shaded-area maps. Figure 104 shows a State map, divided into counties, and shaded according to the percentage of foreign-born white population in each. The key reveals the proportions of which but two intervals are used. The chart is one of many appearing in the United States Census Reports. Note that heavy single hatching can be made to appear more dense than thin double hatching. The names of the counties were lettered on separate paper, and pasted over their respective areas, after the hatching had been completed. This convenient method of lettering can often be used in map charts.

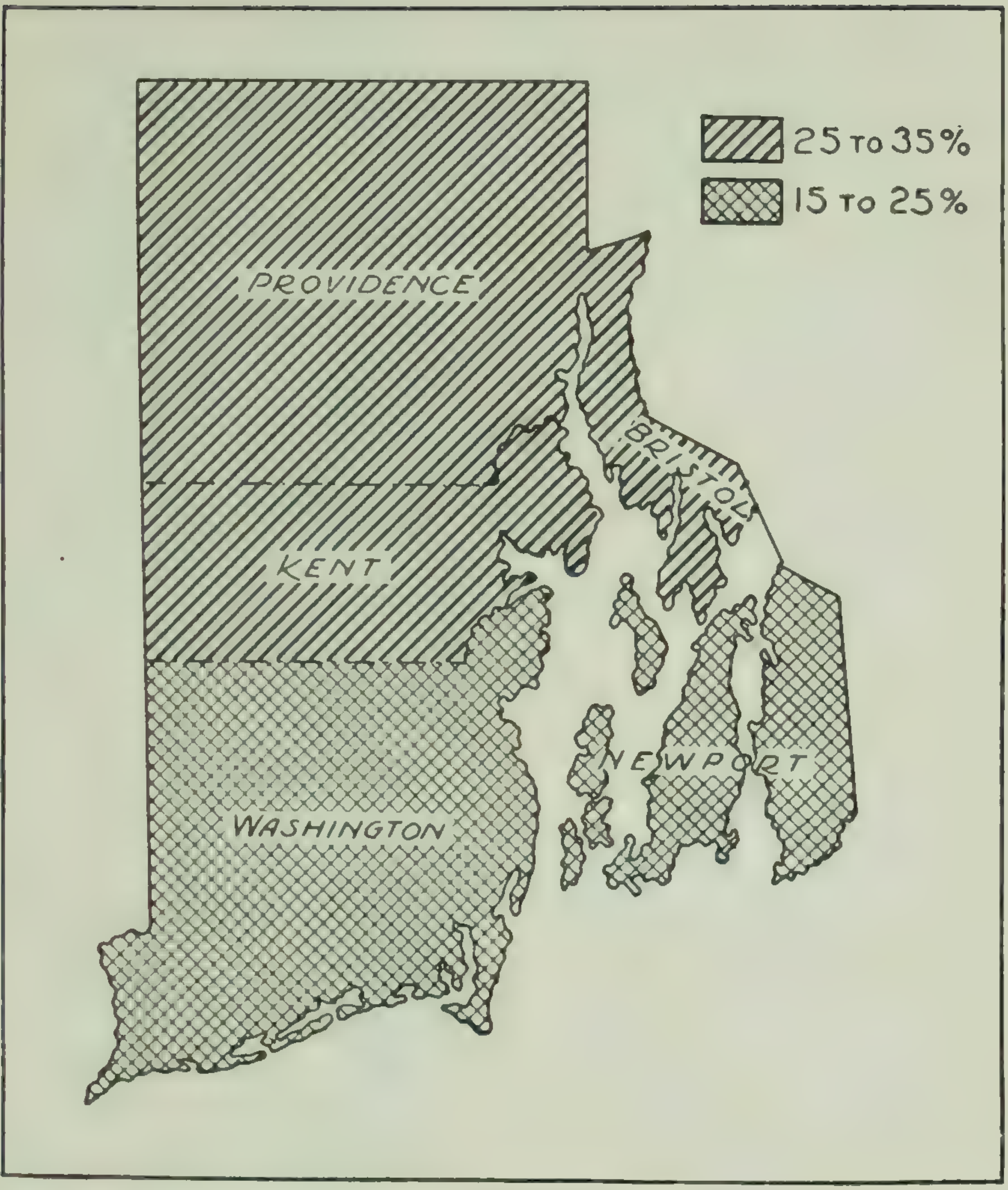


Fig. 104. Proportion of Foreign-Born Whites in the Population of Rhode Island, by Counties

(From *United States Census, Statistical Atlas*, 1914.)

Shaded-area comparative maps. In Figure 105 is shown an excellent method for making comparisons, where several facts relate to the same geographical area. A map of Springfield, Illinois, divided into seven districts, is reproduced four times. Each is then shaded to represent the extent of a certain form of disease. The area representing the most unfavorable conditions is inked-in solid; the area representing the most favorable condition is left white; the other areas are filled in a manner appropriately indicating the disease to which the condition is present. By showing the four maps the fact is brought out that a district favorable to the spread of one disease is not necessarily favorable to the spread of all; the central ward, for example, having the greatest proportion of tuberculosis and the least proportion of diphtheria.

This chart is one of several graphic presentations used in the report of a comprehensive social survey, made under the direction of the Russell Sage Foundation. It is one of the most thorough studies of its kind to have been made in an American city.

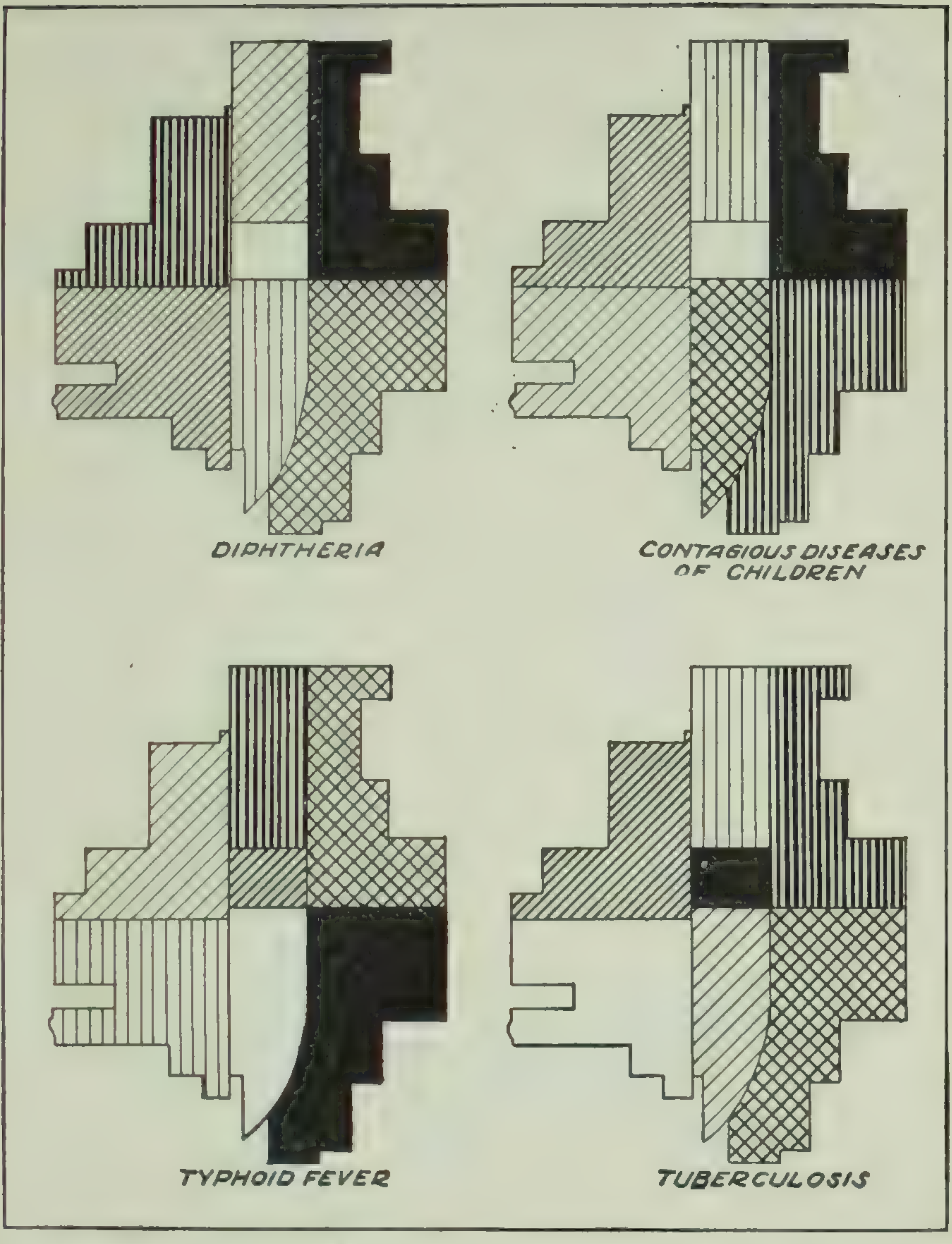
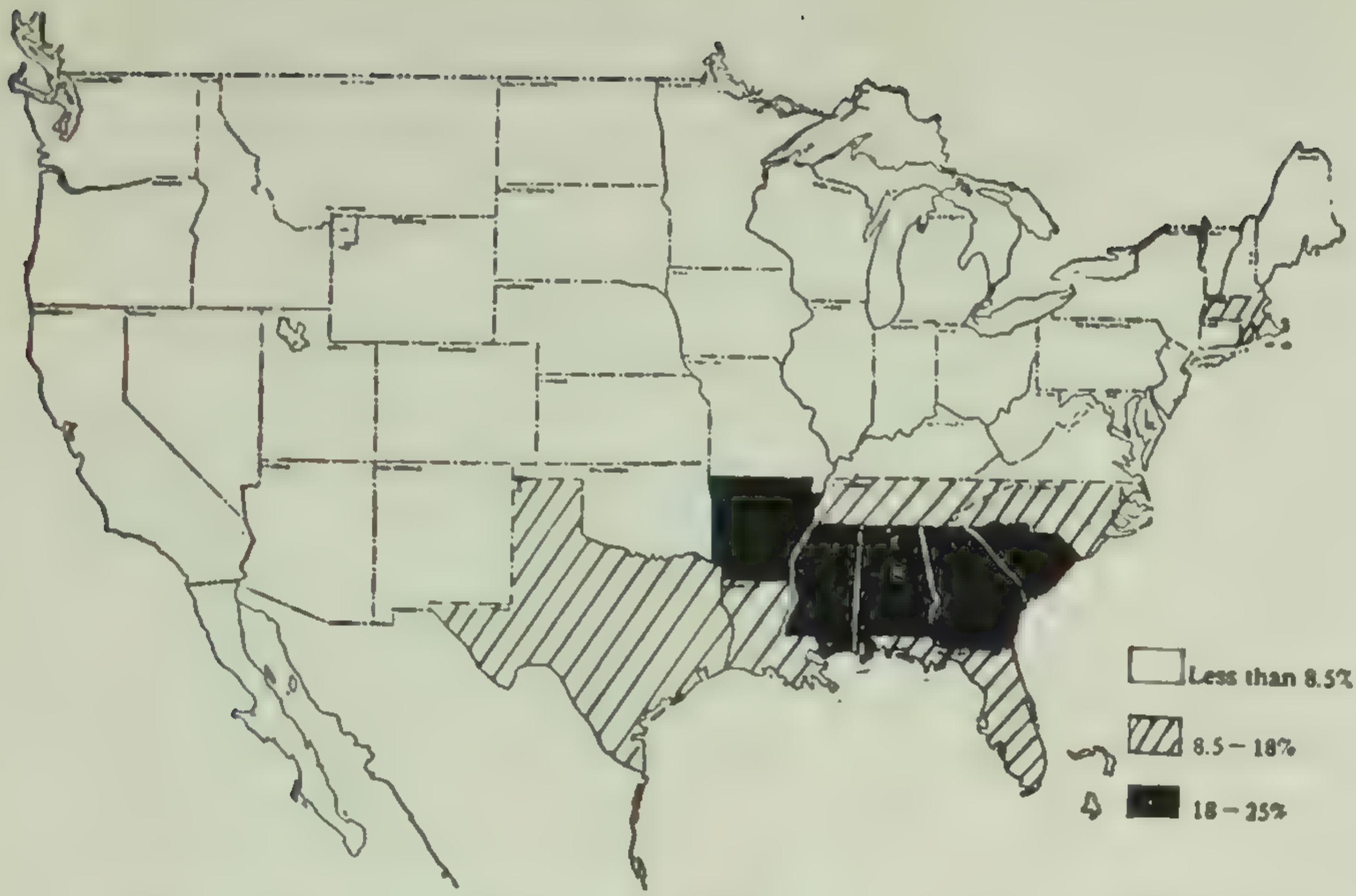


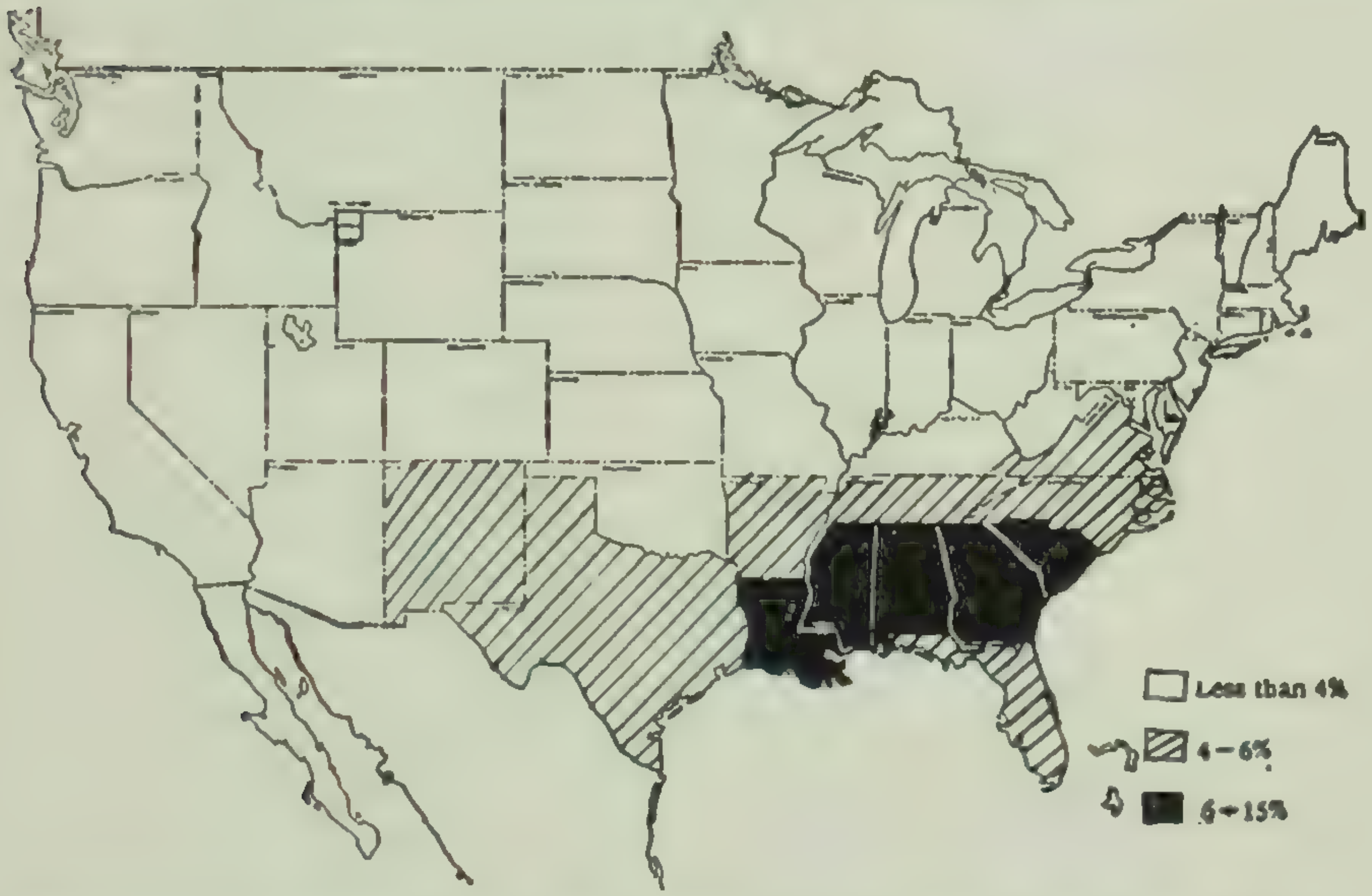
FIG. 105. PREVENTABLE MORTALITY IN SPRINGFIELD, ILLINOIS, BY WARDS
The darker portions indicate the higher death-rates. (From *The Springfield Survey*, by S. M. Harrison.)

Outline-map shading. The story of the child-labor problem is told geographically in Figure 106. These are outline maps of the United States, shaded to show, first, the States employing the most child laborers; second, the States having the greatest proportion of illiterate children. While connection between these facts is verbally implied, the reader cannot help noticing the striking fact that the two evils go hand in hand. Four States appear as inked-in areas on both maps, revealing that the conditions then are the most unfavorable with respect to both of the problems under consideration. The percentages represented by the shading are given in the keys; which, however, are not numerically identical.

In this chart it happens that the inked-in area covers several adjacent States. In order that it may not appear as a single area, the State lines which were covered by the inking are brought out in white. This adds to the effectiveness and accuracy of the chart.



Twelve States employing the most CHILD LABORERS between the ages of 10 and 15 (U. S. Census 1920)



Twelve States having the most CHILD ILLITERATES between the ages of 10 and 15 (U. S. Census 1920)

Fig. 106. Comparative Map, Showing Child-Labor Data for the United States

(From *The American Child*, November, 1922.)

Individual location maps. Figure 107 appeared in the report of a State school survey, made by the United States Bureau of Education. This map is intended to show the large number of consolidated schools — a feature of the school system which was highly commended. The schools occur both in the towns and in the open country, as indicated by the key below the map. Although no comparison with the extent of consolidation for previous years is shown, it is evident that this State has made much progress in the right direction. A comparison with another State, of approximately equal population, might have increased the effectiveness of the chart.

Simple maps of this type can be made of any geographical area, and many important facts can be brought out through the differentiated dot method shown here.

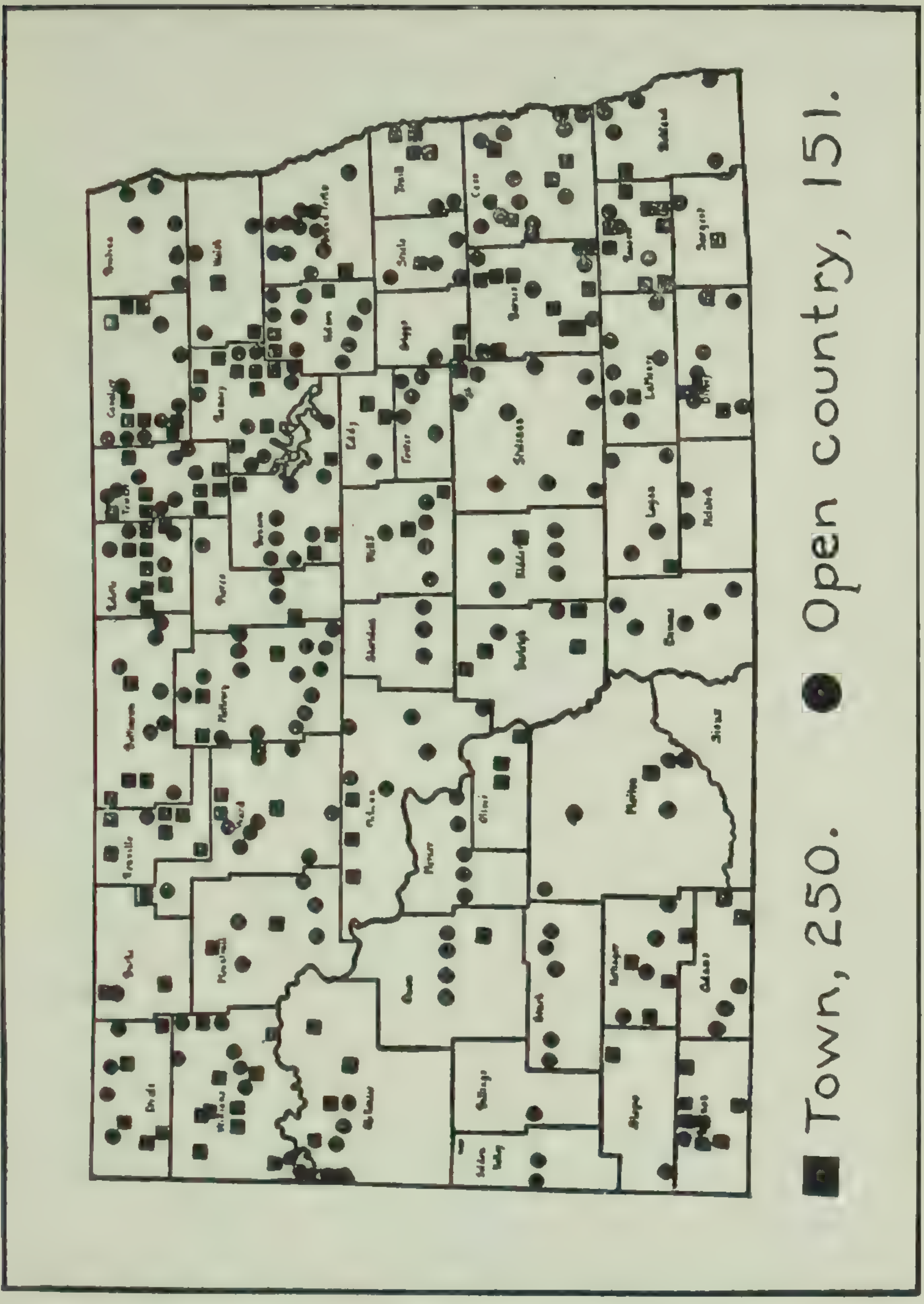


FIG. 107. DISTRIBUTION OF CONSOLIDATED SCHOOLS IN NORTH DAKOTA IN 1914–16

(From United States Bureau of Education Bulletin no. 27. 1916.)

Spot maps. Figure 108 illustrates a form of individual frequency distribution applied to a geographical area. In this instance the map represents the city of Pittsburgh, divided into the numbered districts under the jurisdiction of the health authorities. Each dot represents an infant death in 1920. Through a series of such maps, kept from year to year, and studied in the light of the distribution of population, the effectiveness of the health supervision can be ascertained.

Many uses have been made of spot maps, especially in connection with the use of pins, explained in a later chapter.

The spots on this chart were made with a ball-pointed pen.

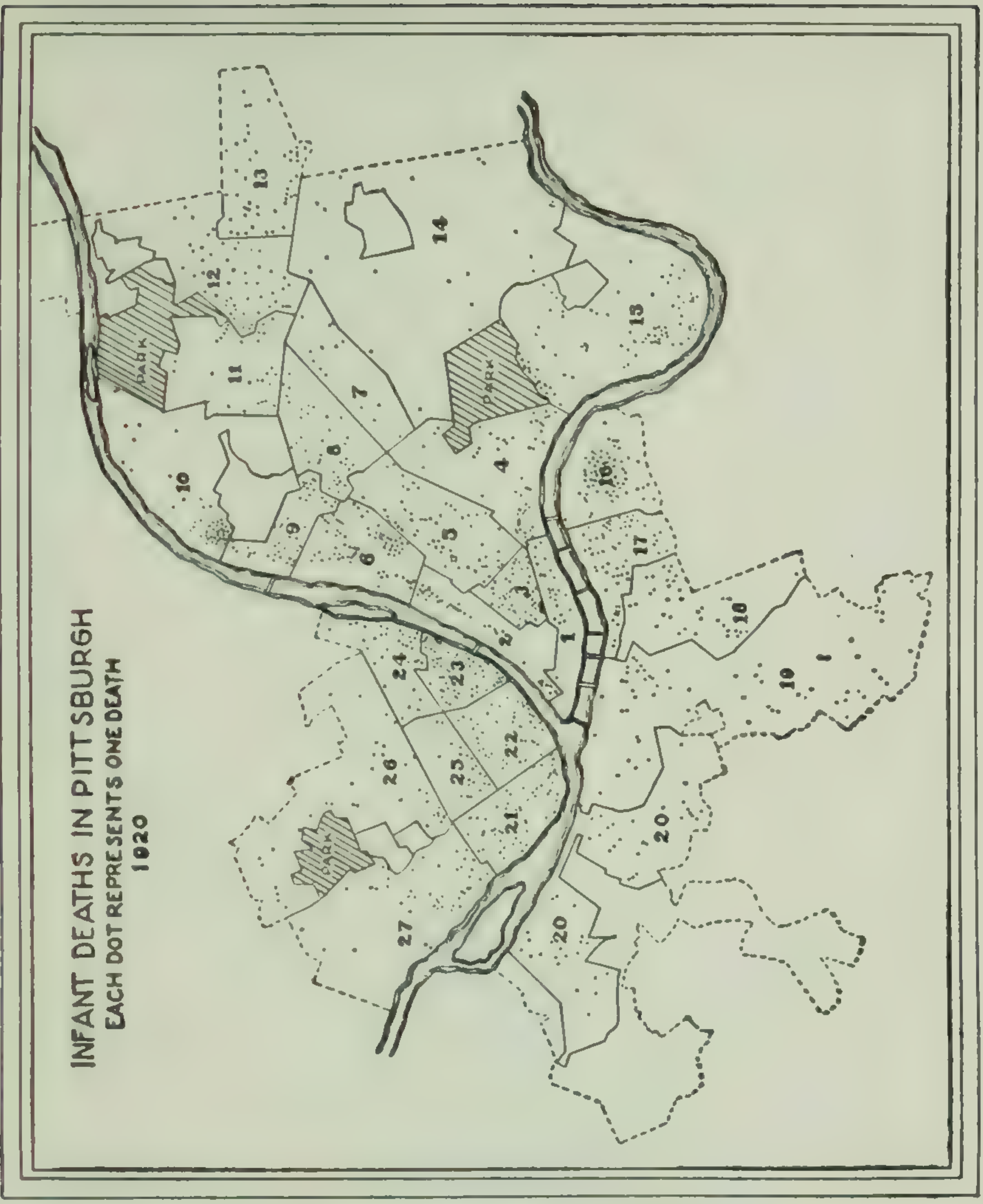


FIG. 108. INDIVIDUAL DISTRIBUTION MAP, SHOWING INFANT DEATHS IN PITTSBURGH IN 1920

(From United States Children's Bureau *Report on Infant Mortality.*)

Migration maps. Figure 109 shows the area from which the tuberculous indigent population of Los Angeles is drawn. The 1171 cases applying for charitable aid, in 1920, who had resided in the county less than two years, were found to have come from nearly every State and several foreign countries. A series of dots is located in each State corresponding to the number of cases. A thin straight line connects each dot with the circle representing Los Angeles. In some cases the patient did not come directly to California, but stopped in another State en route. These cases are shown, with an unfilled circle for the place of temporary residence. Foreign-born patients are represented by dots and lines extending into the ocean. The approximate proportions for several leading countries are indicated in this group.

The map is effective in that the idea of migration is so plainly depicted.

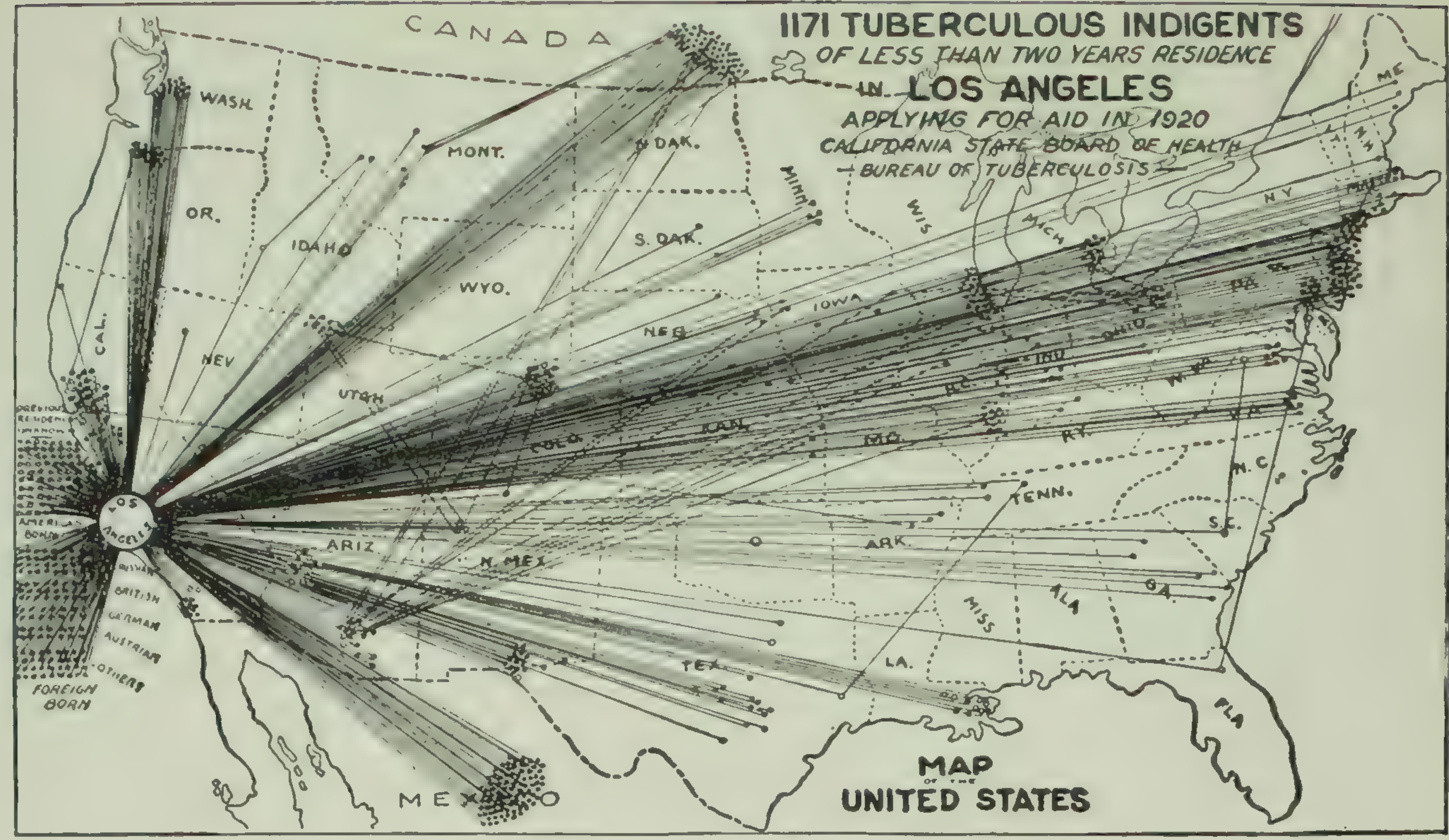


FIG. 109. SOURCES OF TUBERCULOSIS IN LOS ANGELES
(From *Bulletin of California State Board of Health*, November, 1921.)

PROBLEMS FOR CHARTING

1. Draw a district line map showing less regular boundaries than those in Figure 99, and bring out the increased difficulty of making transfers.
2. Locate a school or a public building in your city by a location map, patterned after Figure 100.
3. Make an outline map of your own State, and show the location of universities, colleges, and other important educational institutions, after the manner of Figure 103. Use a special key if necessary, and letter each name distinctly.
4. Show the population-density of several adjacent counties in your State, following the method illustrated in Figure 104. Use the latest obtainable United States Census data.
5. Obtain the directory of a small college with a wide drawing territory, and show the previous residence of the students, as in Figure 109. The broken paths may be used in cases of students who have transferred from other institutions.
6. Work out a shaded-area comparative map of a city which can conveniently be divided into attendance districts, showing the relative attendance in the elementary schools. Use some such classification as the following:

96 to 100 per cent	white
91 to 95 " "	thin single-hatching
90 to 94 " "	heavy single-hatching
86 to 90 " "	cross-hatching
81 to 85 " "	heavy vertical ruling
80 and below "	solid black

7. From recent data show the growth of the junior high school movement in the United States, based on the plan of Figure 106. Outline map can be purchased at school supply houses.

CHAPTER XII

GENEALOGICAL CHARTS

(EXPLAINING FIGURES 110 TO 114, INCLUSIVE)

General definition. Genealogical charts are designed to show family history, with special reference to the inheritance of traits. The graphic representation of a related group of individuals is sometimes referred to as the "family tree," because of the branch-like structure of the chart. Sometimes the purpose of such a chart is to show especially desirable traits; sometimes to show undesirable traits, such as mental deficiency, insanity, etc.; while at other times it is designed to show all of the important traits found in the family, whether favorable or unfavorable.

Genealogical chart-making is a part of the work of eugenics, which is defined as "the study of agencies under social control which may improve or impair the racial qualities of future generations, either physically or mentally." The principles of eugenics have wide practical application, and have recently come into use in connection with special types of educational work, because of the increasing importance attached to developmental facts in the guidance of children.

The principal agency for eugenics in the United States is the Eugenics Record Office, of Cold Spring Harbor, New York, a branch of the Carnegie Institution. The standards for graphic representation of family-history data are presented in Bulletin No. 7, entitled *The Family History Book*, compiled by Dr. Charles B. Davenport. The use of graphic methods in eugenical studies may also be found in recent books and periodicals dealing with human heredity.

In England such work is centered in the Galton Laboratory of the University of London, under the direction of Karl Pearson. This laboratory was founded by Francis Galton, who was first to use the word "eugenics," and whose pioneer work in the study of human traits opened the way for the development of this important science.

Symbols used in genealogical charting. Figure 110 shows the more important symbols used in making eugenical charts. The purpose of the symbols is to make charts reveal as much as possible of the information to be presented, so that the necessity for referring to the verbal explanation may be minimized. This plan of charting, which is now standard procedure for American workers in eugenics, was adopted, in 1910, by a special committee of the American Association for the Study of the Feeble-minded, and is based principally upon the facts related to mental deficiency. Some modifications and additions have been made to accord with recent work, particularly in the field of delinquency. Squares represent males; circles, females. The diamond-shaped figure represents persons to be shown on the chart, but whose sex is not known. The letters within the symbols are the first letters of words representing traits. Other letters, which are usually placed outside, but near, the character symbol, represent other traits and related facts.

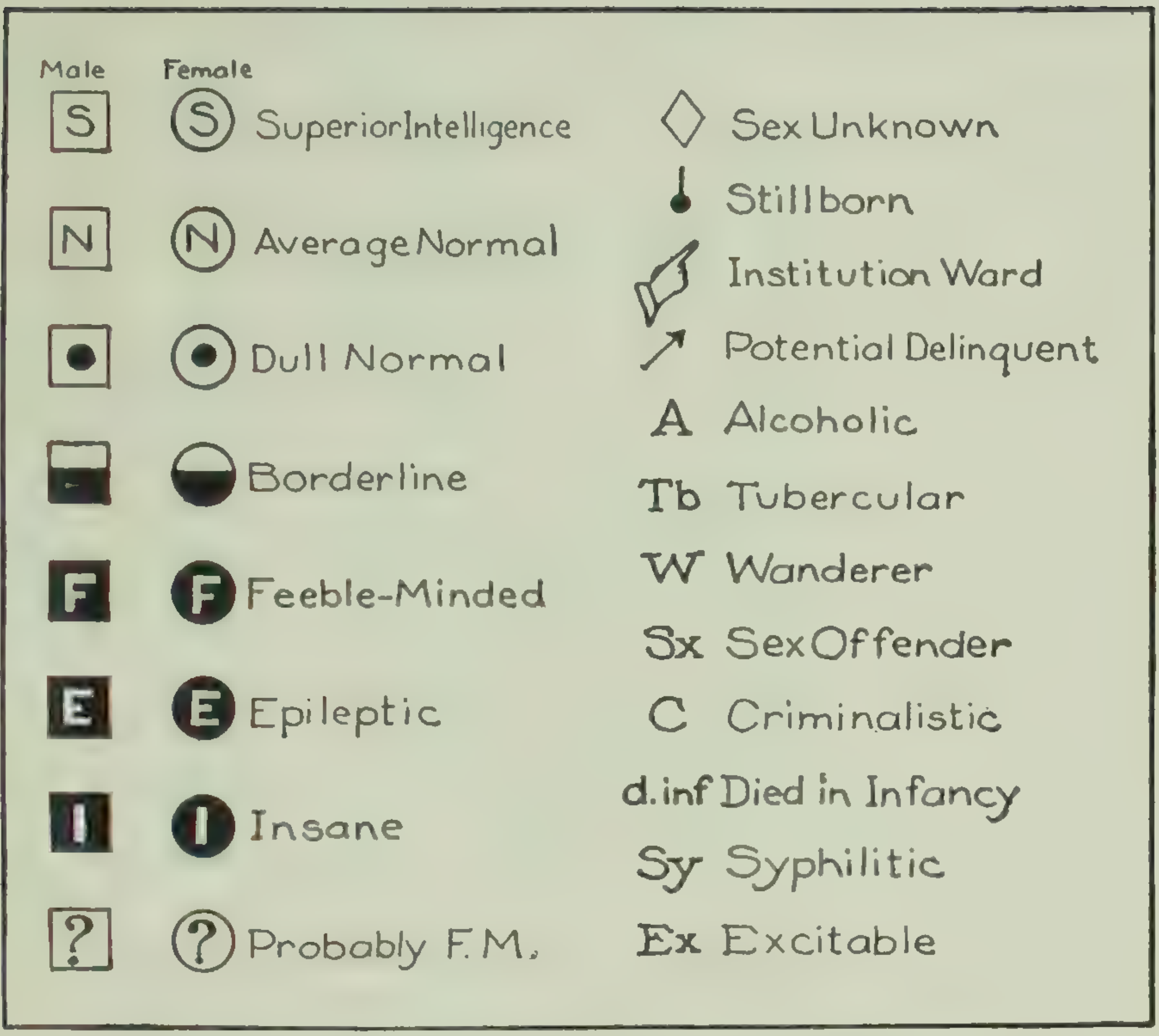


Fig. 110. Symbols Used in Genealogical Charting
(From *The Intelligence of the Delinquent Boy*, by J. H. Williams.)

The Mendelian laws of heredity. Figure 111 is introduced to show the use of symbols in simple family charts, and to illustrate how the entire scope of a comprehensive scientific law can be geographically represented. The Mendelian laws of heredity, applicable to many characteristics of both plant and animal life, are here shown in their application to feeble-mindedness.

Three types of individuals are represented: (1) the *duplex*, in which all germ cells contain the determiner for normal intelligence; (2) the *nulliplex*, in which the germ cells are completely lacking in the determiner for normality; and (3) the *simplex*, in which the external traits resemble those of the duplex individual, but who possesses alternately germ cells with and without the determiner for normality. Thus we have (1) normal persons who are wholly capable of transmitting normality; (2) feeble-minded persons, not capable of transmitting normality; and (3) persons of normal intelligence, whose offspring may be either normal or deficient.

These three types of individuals are capable of six types of mating, shown on the chart in the following order:

1. Duplex — Duplex. (Offspring all duplex.)
2. Nulliplex — Nulliplex. (Offspring all nulliplex.)
3. Duplex — Nulliplex. (Offspring all simplex.)
4. Simplex — Simplex. (Offspring one-fourth duplex, one-half simplex, one-fourth nulliplex.)
5. Simplex — Nulliplex. (Offspring one-half nulliplex, one-half simplex.)
6. Simplex — Duplex. (Offspring one-half duplex, one-half nulliplex.)

This representation of Mendelian heredity in relation to human intelligence is based on the finding that normal (duplex) persons of normal inheritance produce normal children; that feeble-minded (nulliplex) persons, when mated to their kind, produce feeble-minded children; and that the several other combinations of matings produce, in arithmetical proportion, the types of offspring shown.

The relatively large number of normal individuals shown in the chart indicates that normality is *dominant*, and feeble-mindedness *recessive*. With eugenically controlled matings, hereditary mental deficiency could be practically eradicated.

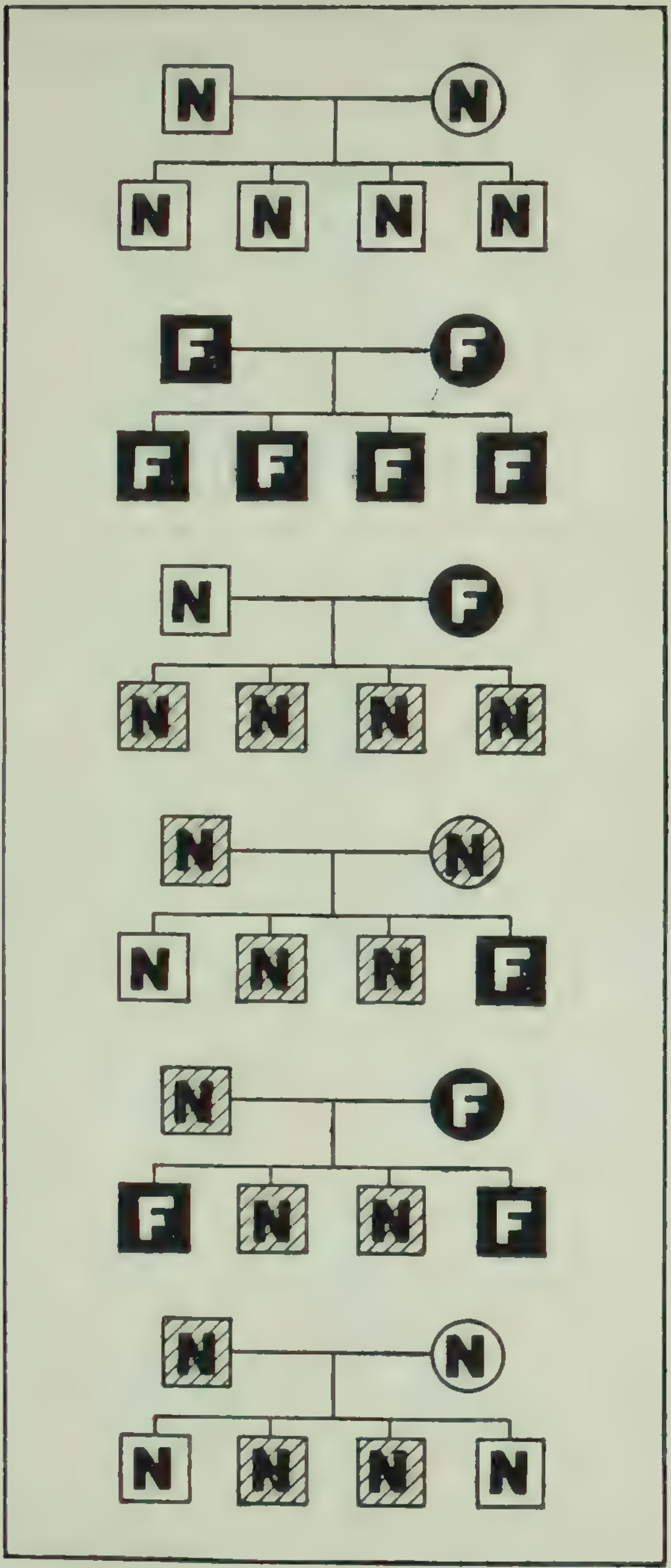


FIG. 111. THE MENDELIAN LAWS APPLIED TO THE INHERITANCE OF FEEBLE-MINDEDNESS

(From data in *Feeble-Mindedness; its Causes and Consequences*, by H. H. Goddard.)

Family history of feeble-mindedness. Figure 112 shows the family chart of a feeble-minded boy, a former inmate of the Training School at Vineland, New Jersey. The chart is a graphic representation of data collected through months of investigation by trained field-workers. Beginning with the boy, called the *propositus* of the study, each member of the family is represented in correct relationship. Each horizontal row of symbols represents one generation. A horizontal line connecting males and females represents marriage. From the center of this line is dropped a vertical line, from which, in horizontal array, are shown the offspring. The prominent feature of this chart are the two feeble-minded parents shown in the second generation, of whose children practically all are known to be feeble-minded. The children's symbols are arranged from left to right to show the order of birth. The *propositus* in this case is the second child.

The following is taken from Dr. Goddard's description of the boy and his family:

CASE 93. KONRAD I. 32 years old. Mentality 6. Has been here 14 years. American born, of American parentage. Was a strong baby. Learned to talk at three years of age, although his speech was defective. He had convulsions when he was two or three years old.

Konrad's father and mother are both feeble-minded, the father being also alcoholic. The mother belongs to a large family, but nothing could be determined as to their mentality. Konrad has had seven feeble-minded brothers and sisters, one died in infancy, one died of black diphtheria, and there was one miscarriage. Some of them are of higher mentality than Konrad.

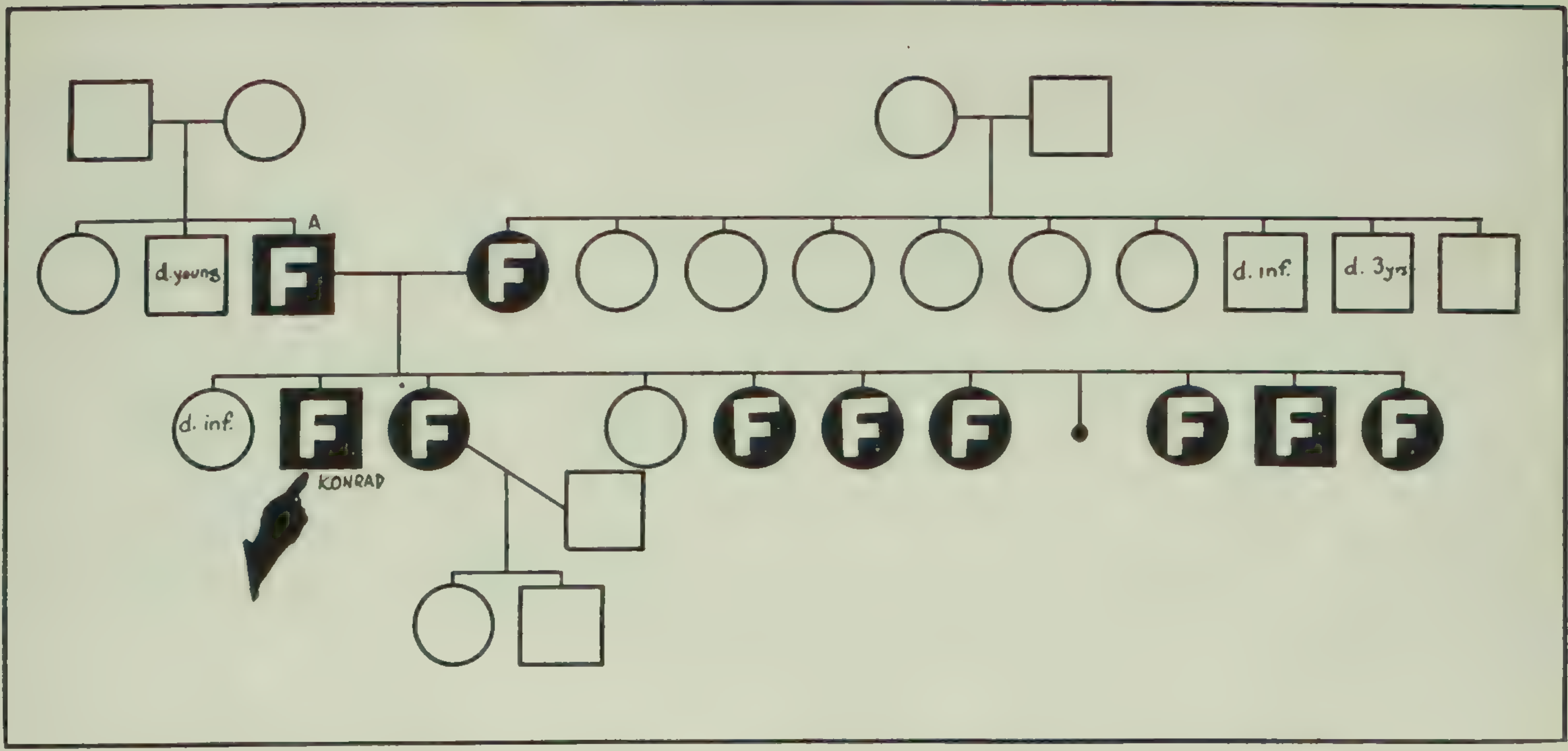


FIG. 112. FAMILY CHART OF A FEEBLE-MINDED BOY IN THE TRAINING SCHOOL AT VINELAND, NEW JERSEY
(From *Feeble-Mindedness; its Causes and Consequences*, by H. H. Goddard.)

Family history of nomadism. The family chart shown in Figure 113 deals with nomadism, or the tendency to wander. The *propositus* of the history is the boy represented by the inked-in square to which the index hand is pointing. This boy was dealt with by the juvenile court as an habitual truant. He was continually running away from school and his home, and seemed unable to remain in any place for more than a short time without becoming restless. The investigation of the family shows that two brothers and a sister of this boy were also nomadic, and that this trait characterized the father, a paternal uncle, and the paternal grandfather. There were also several similar cases on the mother's side of the family. The nomadic cases are indicated by shaded areas, while several semi-nomadic cases are indicated by half-shading.

The generations, of which four are represented, are numbered in sequence by Roman numerals; I, II, III, and IV. Each individual symbol in each generation is numbered in Arabic numbers, reading from left to right in a given family order of birth. In the descriptive matter which usually accompanies such charts the individuals are referred to by a combination of numerals which indicates their place on the chart. Thus the *propositus* is IV–5; his father is III–5; his paternal grandfather, II–1; the mother's father, II–3, etc. The foregoing is the standard system adopted by the Eugenics Record Office, and which is in general use in eugenical field work throughout the United States.

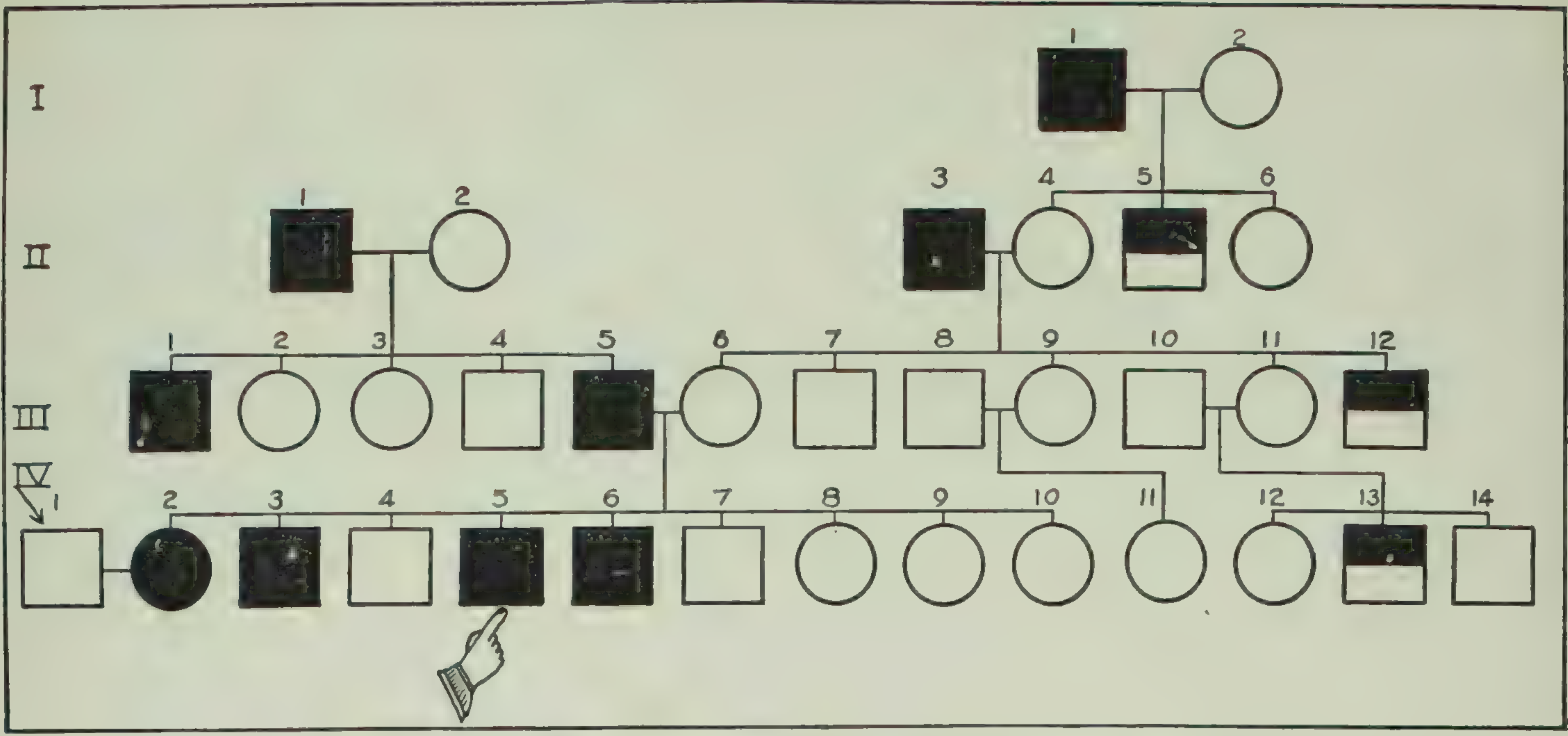


Fig. 113. Hereditary Nomadism in the Family of a Delinquent Boy

Nomadic persons indicated by solid black symbols; semi-nomadic, half-shaded symbols. Squares, males; circles, females. (From *Biennial Report of Whittier State School*, 1915–16.)

Family history of musical talent. An interesting combination of graphic methods is illustrated in Figure 114. This chart, one of many prepared by Dr. Hazel M. Stanton in a study of the inheritance of musical capacity, shows the results of tests for each member of a family for three generations. The purpose of the investigation was to determine the hereditary basis of musical inheritance in certain specific capacities, rather than musical ability as a whole. Following the methods devised by Dr. C. E. Seashore, the members of several families were tested for four of the basic elements of musical talent: (1) pitch discrimination; (2) intensity discrimination; (3) sense of time; and (4) tonal memory. Relative standing according to percentile rank is indicated by a four-fold horizontal profile curve. The heavy vertical line in the center of each cross-ruled section represents average capacity; the parallel vertical lines on either side represent, at the left, five degrees of less than average capacity, and, at the right, five degrees of superior capacity. For example, the first person shown is rated as follows in the four musical capacities studied:

Pitch discrimination	low average
Intensity discrimination	very poor
Sense of time	very superior
Tonal memory	very poor

It will be noted from the other individual charts that there is a general correspondence of capacity ranking; that is, persons who tend to rate high in one trait tend to rate high in others. The individual exceptions, however, constitute a significant application of the study. This ingenious use of graphic representation is to be commended.

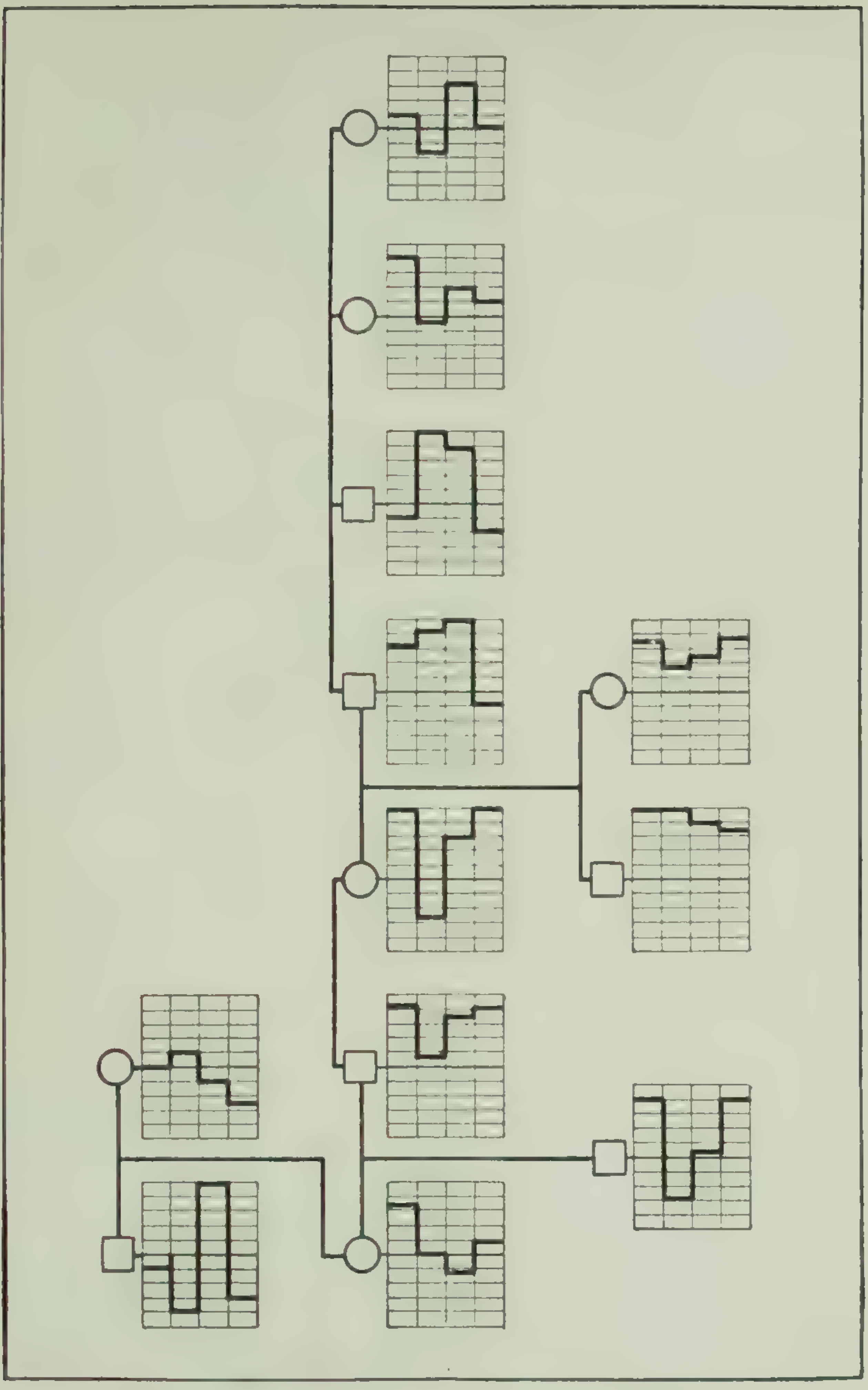


FIG. 114. MUSICAL TALENT PEDIGREE CHART

(From *The Inheritance of Specific Musical Capacities*, by Hazel M. Stanton. Eugenics Record Office, 1922, Bulletin no. 22. Reprinted from *Psychological Monographs*, vol. XXXI, no. 1.)

PROBLEMS FOR CHARTING

1. The Mendelian laws of inheritance, referred to and illustrated in Figure 111, are applicable to human eye-color. Brown eyes may be represented by the duplex and simplex symbols, and blue eyes by the nulliplex symbol. Redraw the six Mendelian combinations for this purpose. For duplex brown use inked-in areas; for simplex brown, double-hatching; for blue, leave the area white.

2. Draw a chart showing at least two generations of your own family, indicating the eye color of each person as in the foregoing problem. Use the index hand to indicate yourself, the *propositus* of the study. The data thus prepared may be checked with the Mendelian expectations by comparison with the previous chart.

3. Copy the chart shown in Figure 113, without filling in the symbols. Then indicate the following, according to the key shown in Figure 110:

   I–2 and III–9 to be of superior intelligence.
   II–3, II–6, III–3, III–7, III–10, average normal.
   III–8, IV–14, borderline.
   III–2, feeble-minded.
   III–6, insane.
   IV–7, potential delinquent.
   III–3, III–6, III–12, wanderers.

4. Copy Chart I, page 36, of *The Kallikak Family*, by H. H. Goddard. (The Macmillan Company, New York, 1914.)

5. Redraw the family chart in *Clinical Studies in Feeble-Mindedness*, by E. A. Doll, page 101. Renumber the characters according to the standard method illustrated in Figure 113. It will be possible to condense the chart horizontally by careful planning.

6. Redraw charts from *Dwellers in the Vale of Siddem*, by Rogers and Merrill.

7. Copy the diagrammatic permutation chart on page 23 in *The Mechanism of Mendelian Heredity*, by Morgan and others.

8. Duplicate the chart on page 118 of *Being Well-Born*, by M. F. Guyer.

9. Construct a chart of Mendelian inheritance from the plan on page 236 of *Heredity and Environment*, by E. G. Conklin.

10. Chart the diagram on page 78 of *Mendelism*, by R. C. Punnett, noting the English type of characters.

CHAPTER XIII

ARCHITECTURAL DIAGRAMS

(Explaining Figures 115 to 118, Inclusive)

General definition. Architectural diagrams are descriptive sketches, usually of buildings or grounds. They are not drawn according to architectural specifications or technique, but may be used to convey an idea for architectural consideration. They may also be used in presentations not requiring the skilled work of a draftsman, to describe graphically a ground plan or structure.

An illustration of such a plan is shown in Figure 115. This drawing appeared in a State report, and represents a proposed building for a special type of State service. The general arrangement of the building, with its three main sections, is the principal feature to be brought out. The readers of the report were not concerned with the exact structural details which an architect's final drawing would show. In fact, such a detailed drawing might be lacking in the interest-value of the simpler diagram. The general arrangement of a new building may be of considerable popular interest.

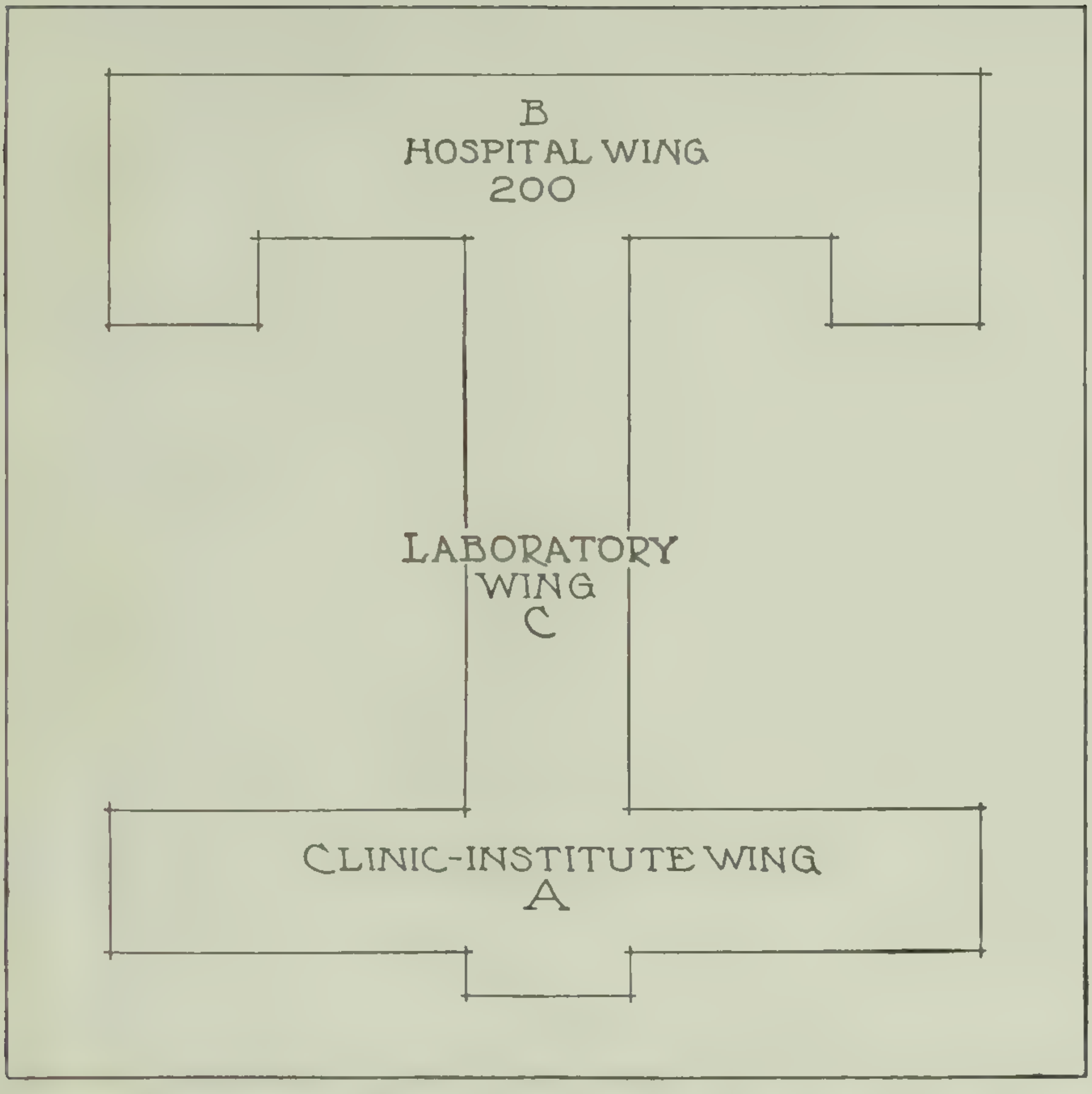


FIG. 115. DIAGRAMMATIC PLAN OF PROPOSED BUILDING FOR A PSYCHIATRIC INSTITUTE HOSPITAL IN NEW YORK

(Redrawn from a chart in *State Hospital Bulletin*, November, 1922.)

Location of buildings and grounds. School surveys often include studies of buildings and grounds, especially from the standpoint of administrative efficiency and the health of the children. The use of graphic methods in presenting findings is illustrated in Figure 116. *The Boise Survey*, from which this diagram is reproduced, devoted one chapter to an analysis of school property. It was frequently found that buildings were placed on the grounds without due regard to orientation, which "has been determined by chance rather than by the requirements of school efficiency." The report continues:

The position of the building on the site is another important matter in which external appearance, rather than utility, is permitted to be the deciding factor. Many of the Boise buildings are located at such points that an efficiency playground cannot be made from the remaining space. The Park School (illustrated in the diagram) is an example of such placing.

The plan presented here was drawn from measurements made by the pupils of the school, under the direction of the principal, who made of it a project-problem. The site consists of a triangular piece of ground, on which the buildings were so placed that the remaining part was useless for playground purposes. One small corner, it will be seen, is devoted to lawn. Such facts could not easily be brought out without graphic aid, and the many uses of such method will be apparent.

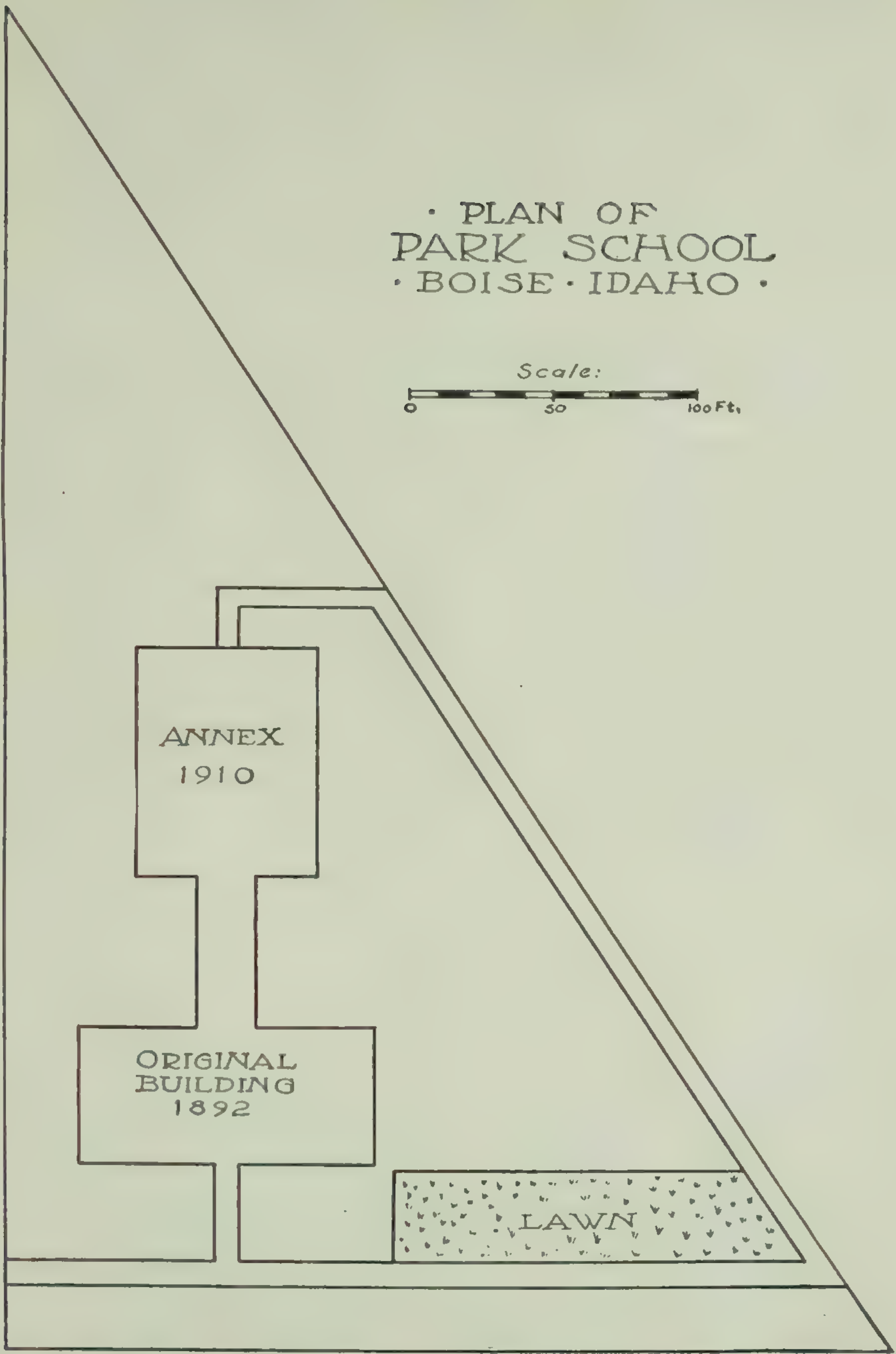


FIG. 116. PLAN OF BUILDINGS AND GROUNDS OF THE PARK ELEMENTARY SCHOOL, BOISE, IDAHO

Measurements made by the pupils of the school. (From *The Boise Survey*, by J. B. Sears.)

Floor-plan sketches. Still more detailed drawings may be made without requiring the services of a draftsman, as may be seen in Figure 117. The subject of this sketch, which appeared in a bulletin of the United States Bureau of Education, is the plan of a teacher's cottage on the grounds of a rural school in Colorado. The exact measurements are given for the more general dimensions, but detailed measurements are omitted. The drawing gives an excellent idea of the appearance of the dwelling, its practical utility and economy. The bulletin from which the plan is reproduced points out the many advantages of providing such dwellings in remote districts. The graphic presentation adds much to the value of the description. Diagrams of this sort can be made by any one who can successfully follow the directions for the practice charts in Chapter II of this text. Note the methods of indicating inside and outside measurements without unnecessary duplication.

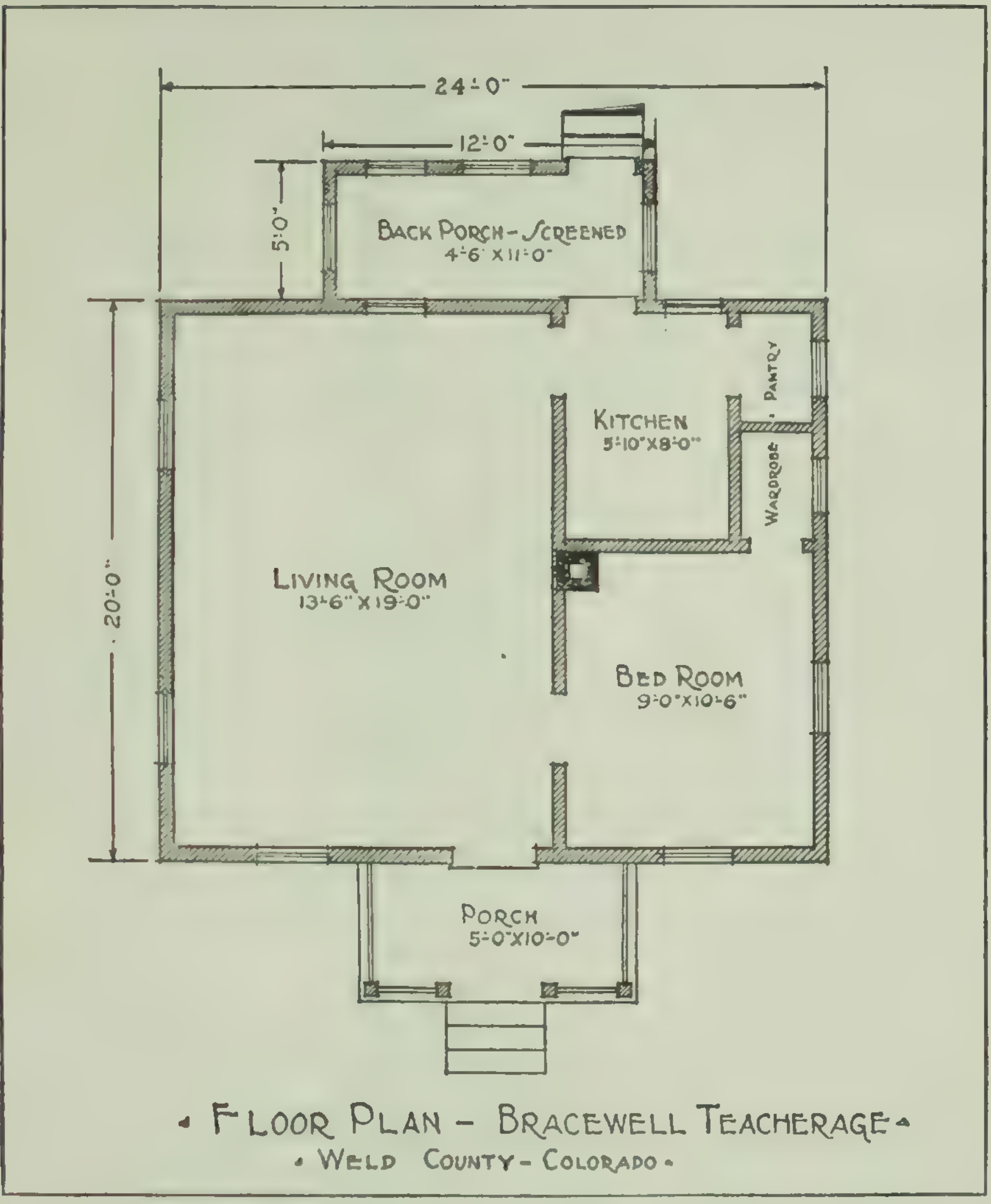


FIG. 117. SIMPLE FLOOR-PLAN SKETCH FOR TEACHERAGE IN COLORADO
(From United States Bureau of Education, Bulletin no. 16. 1922.)

Apparatus diagrams. Figure 118 is a diagrammatic sketch showing the internal arrangement of apparatus used in psychological experiments with animals. The illustration is used only for the technical descriptions of an experiment which is not of popular interest, but even among persons familiar with this work the graphic presentation is essential to a correct evaluation of the results. The verbal description which accompanied the drawing explains the apparatus with the aid of the key letters A, B, E, O, etc., so that the reader may readily refer to the diagram. If the drawing had been omitted it would be necessary for the reader of the experiment to form and retain a visual image of the apparatus, which is not easy to do, and which increases the likelihood of misunderstanding. Scientific writers have long since recognized the value of diagrammatic sketches accompanying technical articles.

How the use of illustrative material facilitates understanding of the technique of experimental work is indicated by the following passage, describing the discrimination box:

In the final form of his experiments Yerkes' apparatus consisted of a nest-box, opening, by means of a swinging door, into a second compartment, the entrance chamber. At the opposite end of this second chamber were two square apertures, each of which formed the entrance to a box (the discrimination or electric-box) communicating with an alley that led back to the home-box; either alley could be blocked at will. The floor in both discrimination-boxes consisted of an oak board carrying electric wires that were connected up with an induction apparatus. The general arrangement was such that the shock could be given in either box, as desired, provided that the circuit was completed by the dancer's feet being in contact with two of the wires, on the floor of the box. Each discrimination-box was illuminated independently by the light from incandescent lamps directly above them. . . . A mouse choosing the compartment which displayed this degree of illumination found a clear passage direct to the nest; whereas entrance into the other compartment was punished by an electric shock, coupled with the fact that the nest could only be regained by an indirect route. (From *Mind in Animals*, by E. M. Smith.)

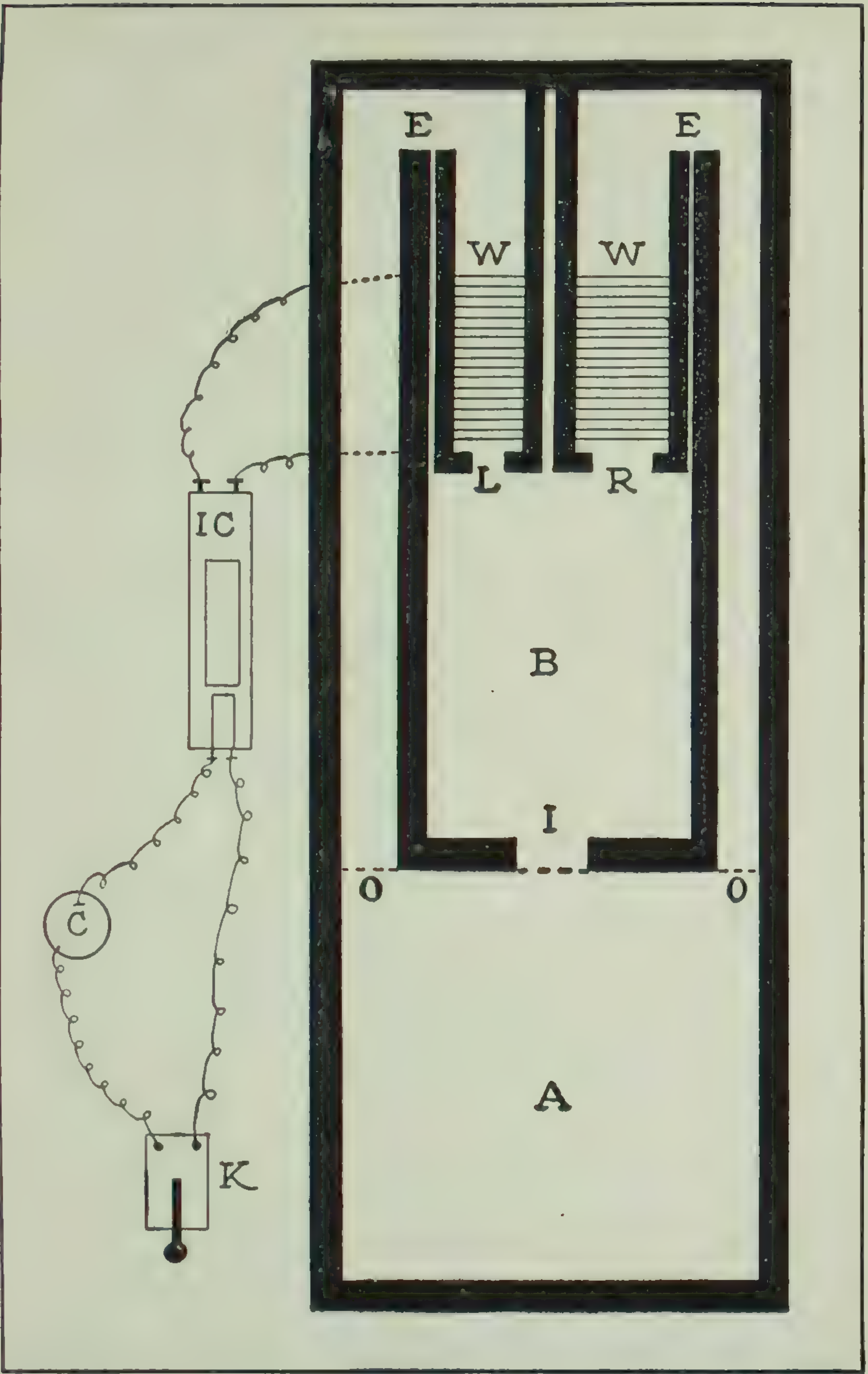


FIG. 118. DIAGRAM OF DISCRIMINATION BOX DEVISED BY PROFESSOR R. M. YERKES, FOR EXPERIMENTATION IN ANIMAL PSYCHOLOGY
(From *Mind in Animals*, by E. M. Smith.)

PROBLEMS FOR CHARTING

1. Draw a simple plan of a school building with which you are familiar, following the general sketch method of Figure 115. It is not necessary that the plan be drawn exactly to scale, although the proportions should be approximately correct. Buildings of unusual shape, having several projections or wings, lend themselves well to the purpose.
2. Draw the building and ground plan, following Figure 116, of a school plant to which you have access. If practicable, have the older pupils of the school take the measurements. Show all buildings, drawn in correct proportion, together with the location of sidewalks, gates, steps, playground apparatus, etc. Letter the name of the school on the diagram, and insert a scale of feet, as in Figure 116.
3. Draw a single floor plan of a small residence in detail, approximating that of Figure 117. The larger measurements, at least, should be drawn to scale. The name of each room, together with its inside dimensions, should be indicated in the center of the space by which it is represented.
4. Find, in a book or magazine, a diagrammatic sketch of a piece of apparatus, and redraw it, without the details unnecessary to a non-technical description.
5. Redraw the sketch of a simple septic tank for a country school, from *School Hygiene*, by F. B. Dressler, page 129.
6. Make a sketch of the device for washing and humidifying the air of a school. from page 210 of Dressler's *School Hygiene*.
7. Draw a sketch of the ideal classroom for an ungraded room according to the suggestions of H. H. Goddard in his *School Training of Defective Children*, chap. III.

CHAPTER XIV

PICTURE GRAPHS

(Explaining Figures 119 to 134, Inclusive)

General definition. The charts reproduced in this chapter illustrate the use of pictures or sketches of real objects for the purpose of bringing out an idea or comparison. Such charts are often used for popular, non-technical matter, but they also appear in highly scientific presentations. In view of the self-explanatory character of the picture graphs, they will not be described on separate pages, but will accompany this series of brief statements.

Objects chosen for pictorial representation of facts should be simply and clearly drawn, and be easily recognizable. Too much emphasis on detail may serve only to distract the reader's attention from the real message. Pictures should be appropriately selected, with special reference to the laws governing the association of ideas.

Various types of picture graphs. Figure 119 is reproduced from Professor Cubberley's discussion of the democratic origin and structure of the American public school system. Unlike the systems of other countries, it may be represented by a series of steps on a ladder — an unbroken sequence from the first grade of the primary school to the final year of the university. The ladder is symbolic of educational achievement, and the order of the academic stages is fittingly shown by the order of the steps one would take in climbing a real ladder. Although but slightly more difficult to draw than a bar chart, the greater effectiveness, especially for the lay reader, is obvious.

Figure 120 is the "infant mortality thermometer" of the civilized world. The degrees in this case do not represent temperature, but indicate the number of infant deaths per 1000 births each year. The height of the mercury column is made to correspond with the record for the United States, with which the other countries are compared. The use of both sides of the page for naming the countries saves the necessity for crowding, especially at the region of most common frequency, between 50 and 100. The mental association of thermometers with health conditions makes this presentation especially appropriate.

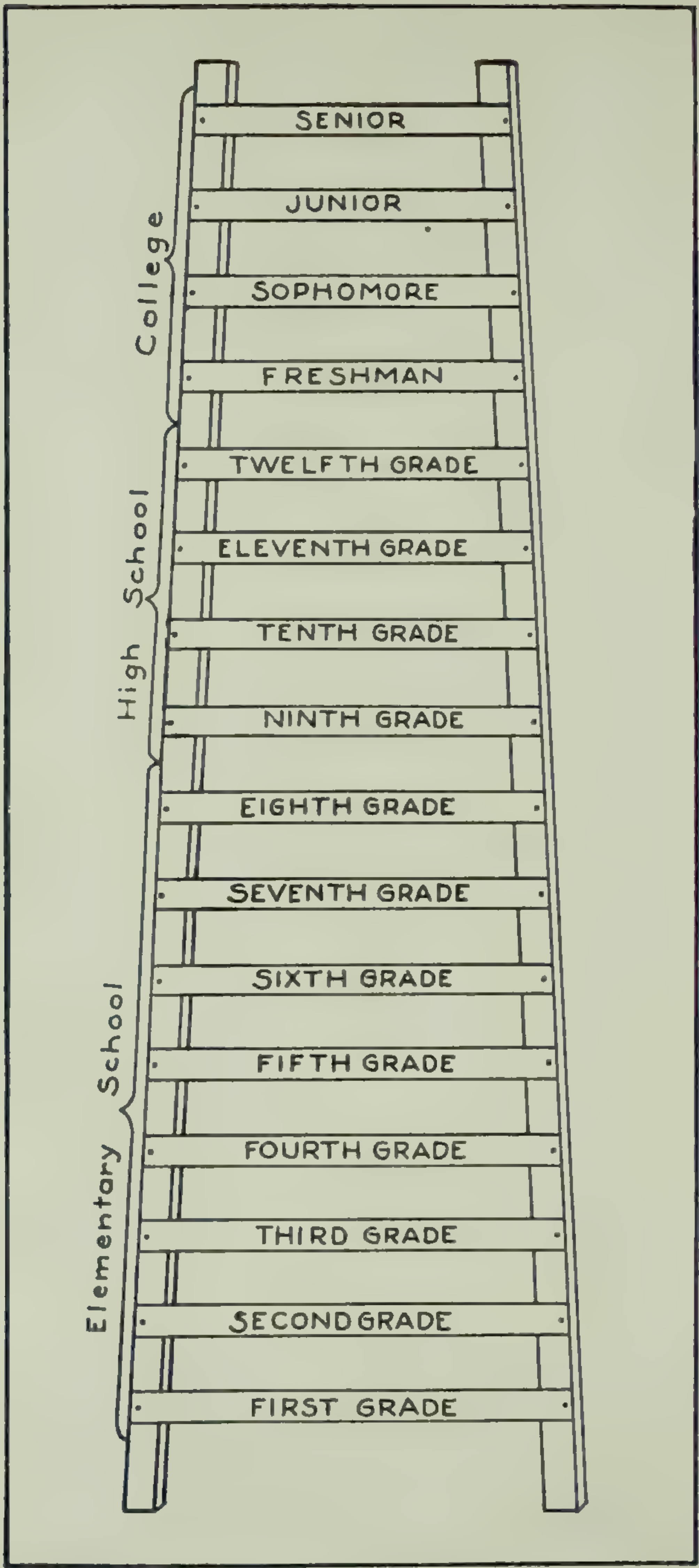


FIG. 119. THE AMERICAN EDUCATIONAL LADDER SHOWING THE CONTINUITY OF THE AMERICAN SCHOOL SYSTEM

(From *Public Education in the United States*, by E. P. Cubberley.)

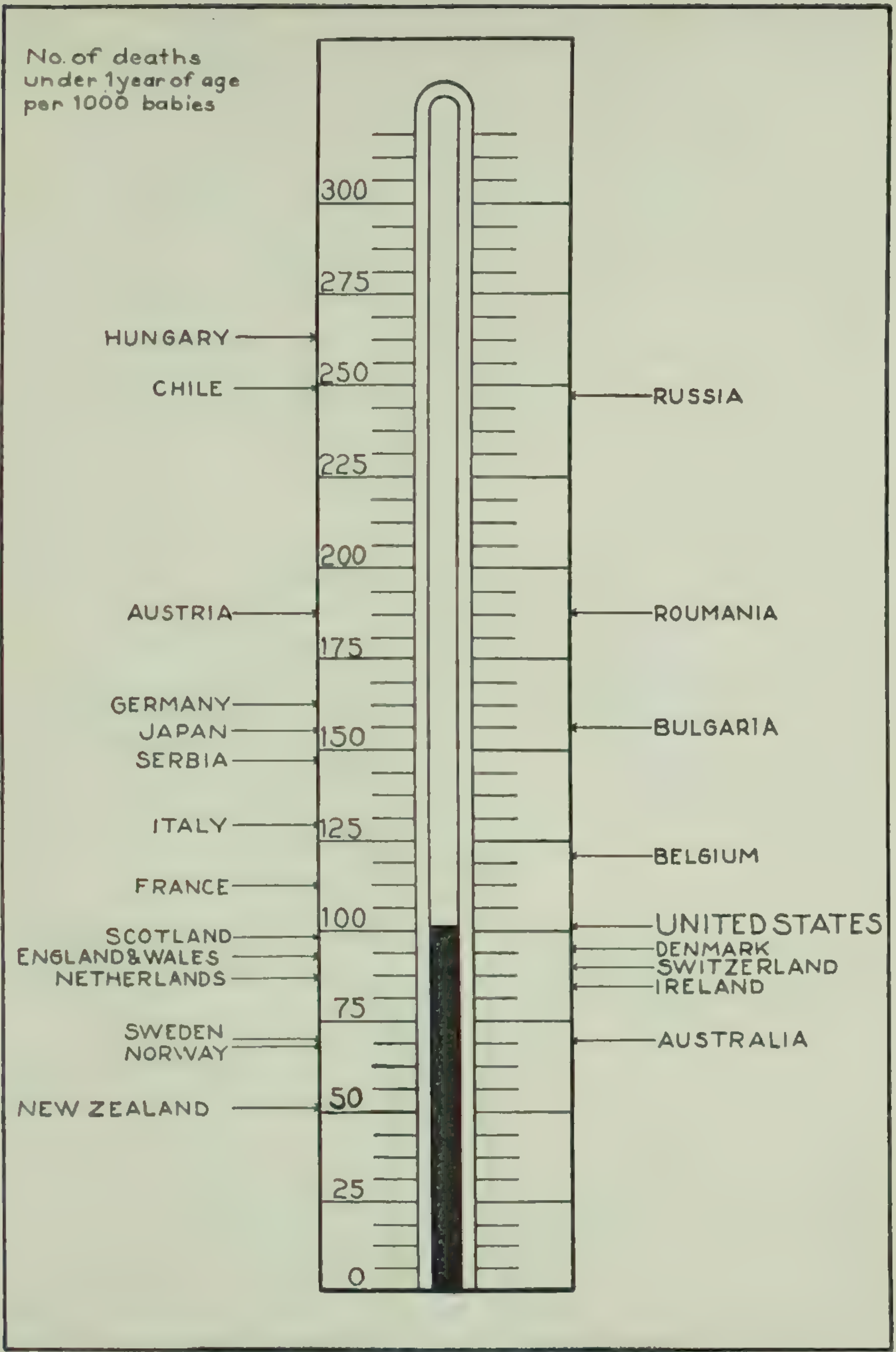


FIG. 120. INFANT MORTALITY RATES FOR 1916
(From United States Children's Bureau, Publication no. 61.)

Vision graphs. Figure 121 shows the three types of vision, with special reference to the mechanism of retinal imagery. The drawings are diagrammatic, for they are not actual pictures of the eye, but the crystalline lens and the retina are shown in their approximate functional relationship. The upper figure shows the rays of light focused exactly on the retina, resulting in normal vision. The second part shows the rays focused behind the retina, resulting in long-sightedness. The bottom part shows the mechanism of short-sightedness, in which the focal point of the rays does not reach the retina. This simple explanation of vision with the obvious relationship to the need for corrective glasses, is impressive to any one interested in the subject, and has popular instructional value.

The descriptive matter accompanying the diagrams is as follows:

In the working of the visual camera four possibilities are always present:

(1) The distance from the lens to the retina may be exactly sufficient to permit rays of light from distant objects (parallel rays) to be brought to a focus upon the retina. This condition is called "emmetropia" (normal vision).

(2) If the distance from the lens to the retina is too short, the parallel rays strike the retina before they have been brought to a focus, thus giving a blurred image. This condition is "hyperopia," or "far-sight."

(3) Sometimes the eye is too long from front to back, so that parallel rays are brought to a focus before they strike the retina. This condition is known as "myopia," or "near-sight." (From Terman's *Hygiene of the School Child*, pages 247–49.)

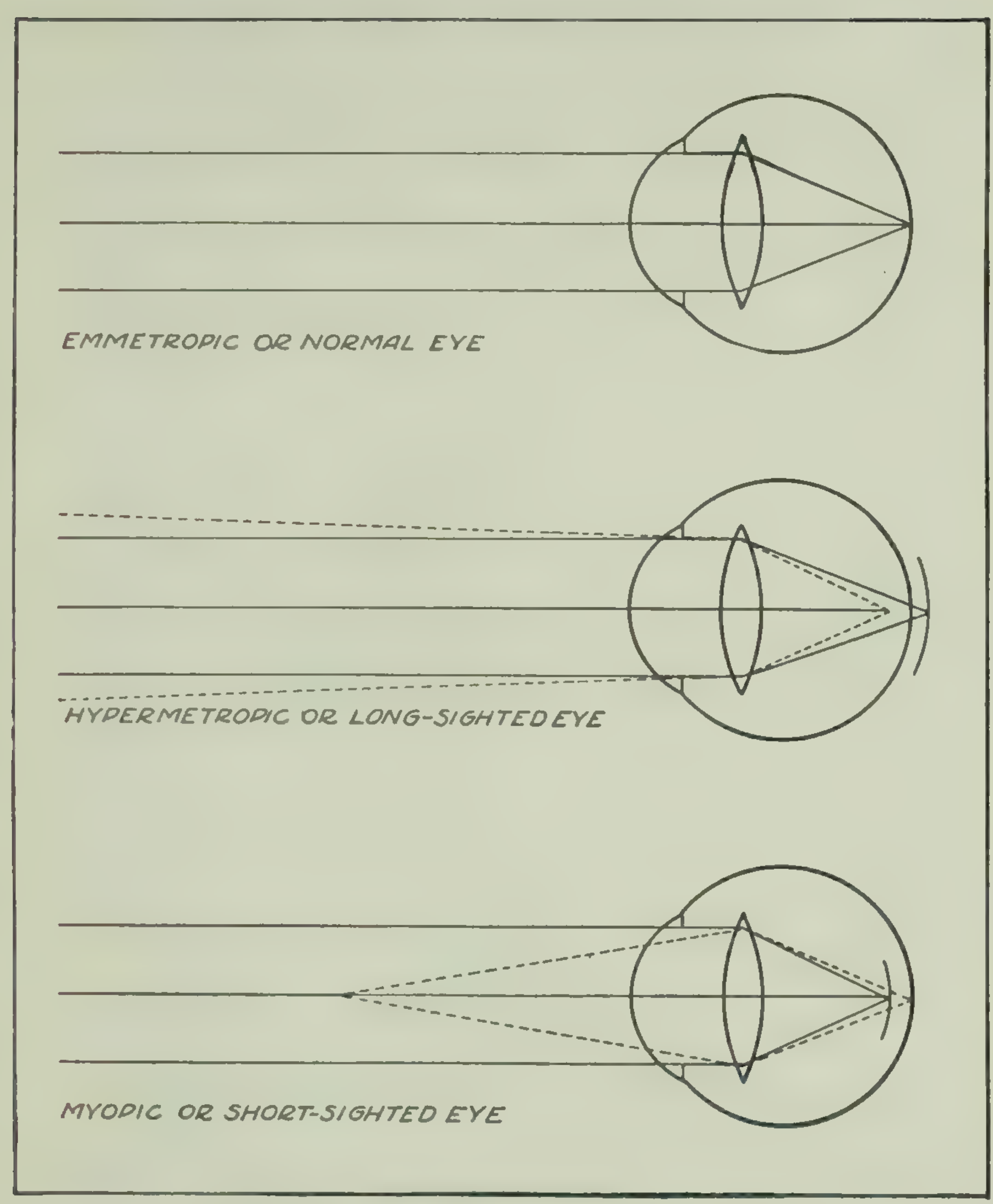


FIG. 121. THE MECHANISM OF VISION
(From *Hygiene of the School Child*, by L. M. Terman.)

Milk-contents graph. Figure 122 shows graphically and numerically the contents of a bottle of milk. Although the presentation is no less technical than a segmented vertical or horizontal bar, the holding power of this chart for a popular audience is greater. Care must be taken in such a diagram to accurately represent the percentages at the upper part, where the dimensions change as the bottle becomes narrow. The use of the numerical data tends to minimize erroneous impressions. The chief value of the chart is its holding power for statistical presentation.

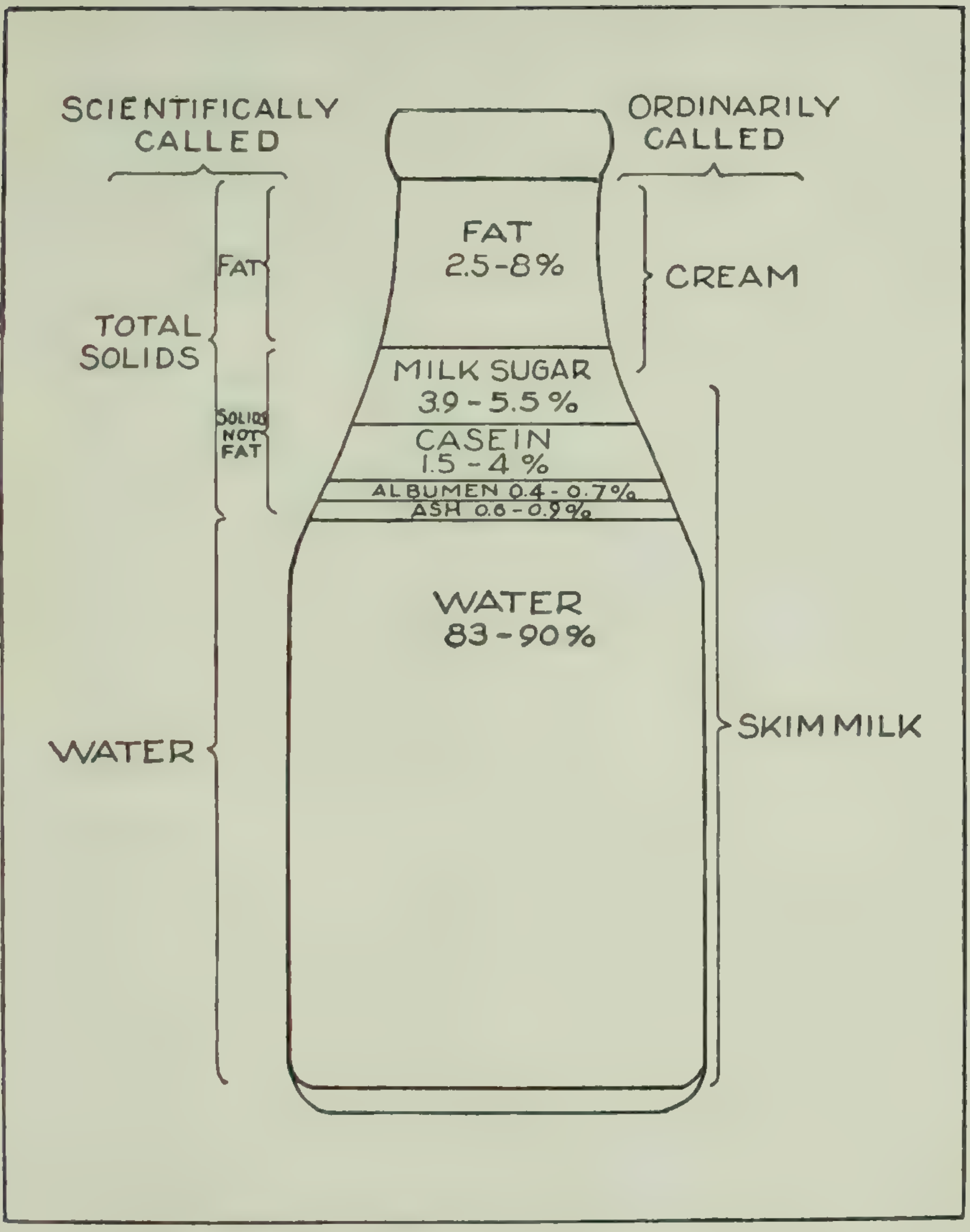


FIG. 122. THE CONTENTS OF A BOTTLE OF MILK
(Redrawn from a chart in *Health and Efficiency*, by J. D. McCarthy.)

Other forms of picture graphs. Figure 123 represents a form of chart frequently used in geographies. The heights of the mountains are represented by the scale at the left and the relative lengths of the vertical dotted lines. The contour is drawn in without reference to actual topography; in fact, the features are distorted so that the eight mountains may be represented on one page. The popular appeal of such a diagram, however, is greater than that of a vertical column chart, which would be its technical equivalent.

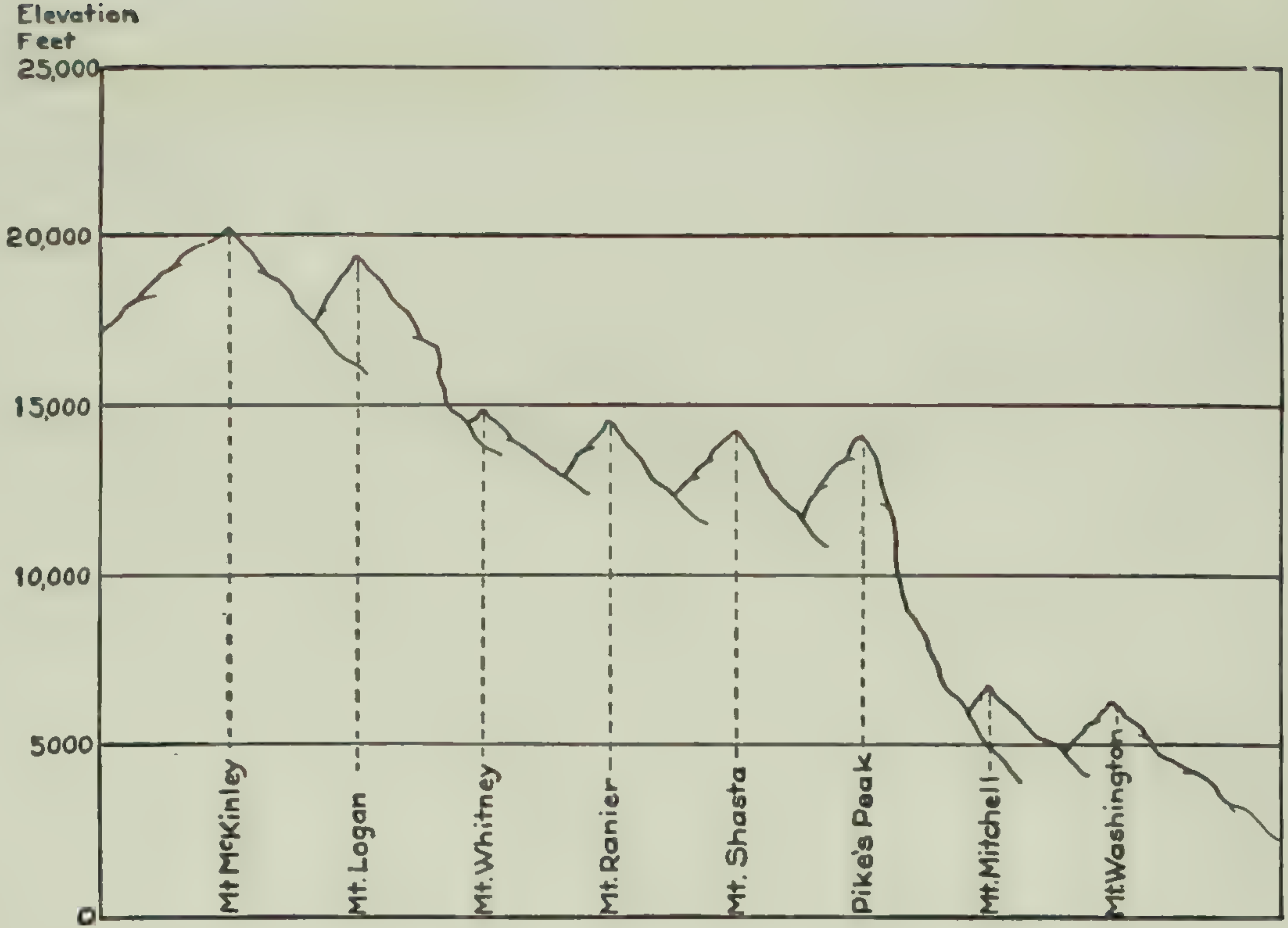


Fig. 123. Relative Elevations of Principal Mountains in North America

Figure 124 has no purpose other than to focus the reader's attention on the five things which make for health. The hand is symbolic of the body, and the number of items happened to accord with the number of fingers. The appeal in this instance is intended for children.

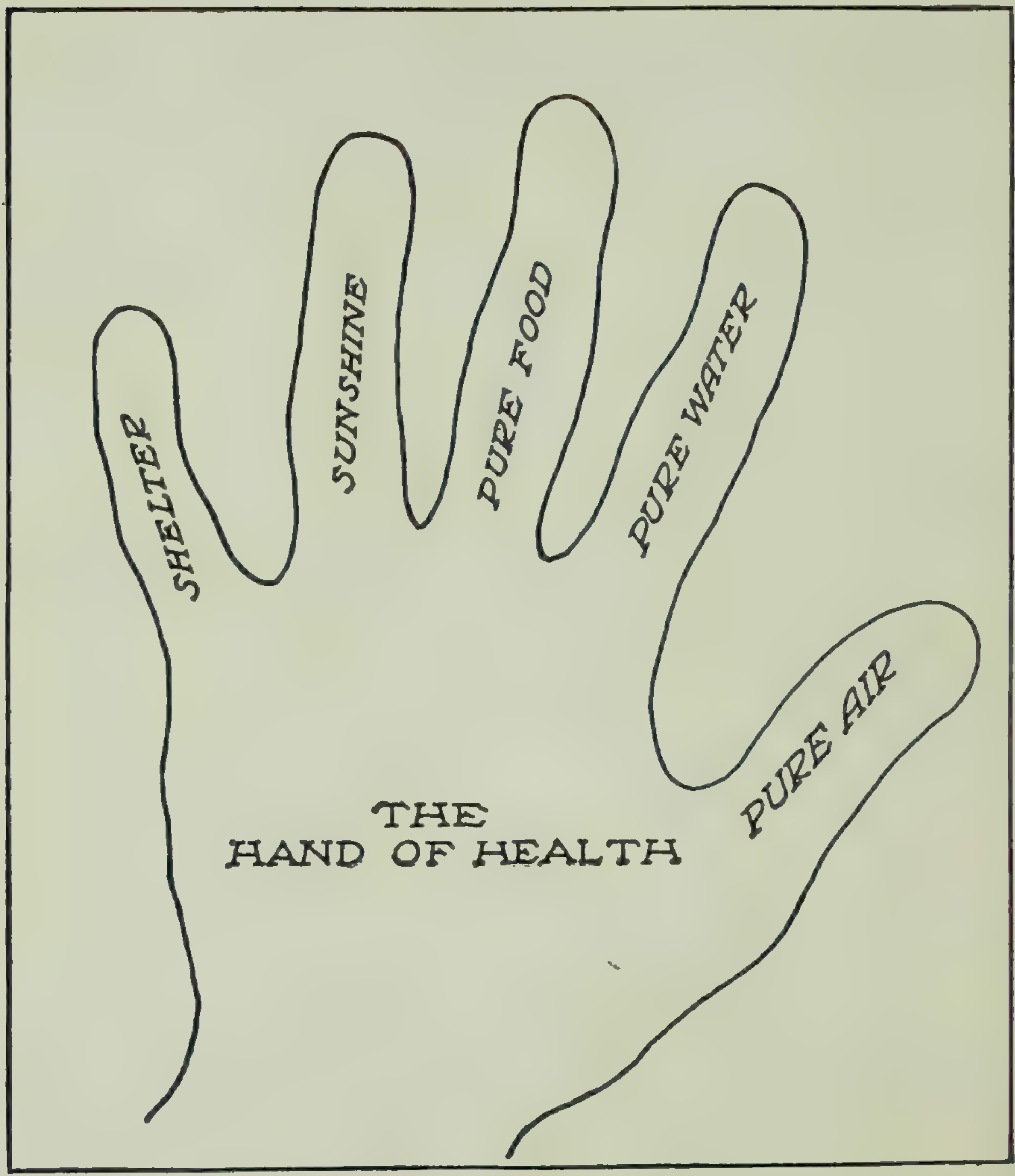


FIG. 124. THE HAND OF HEALTH
(From *Community Civics*, by Ames and Eldred.)

Figure 125 is a comparative pictorial sketch, showing the position of the soft palate in two types of vocalization. The diagram is used in connection with the teaching of the English language in Americanization work.

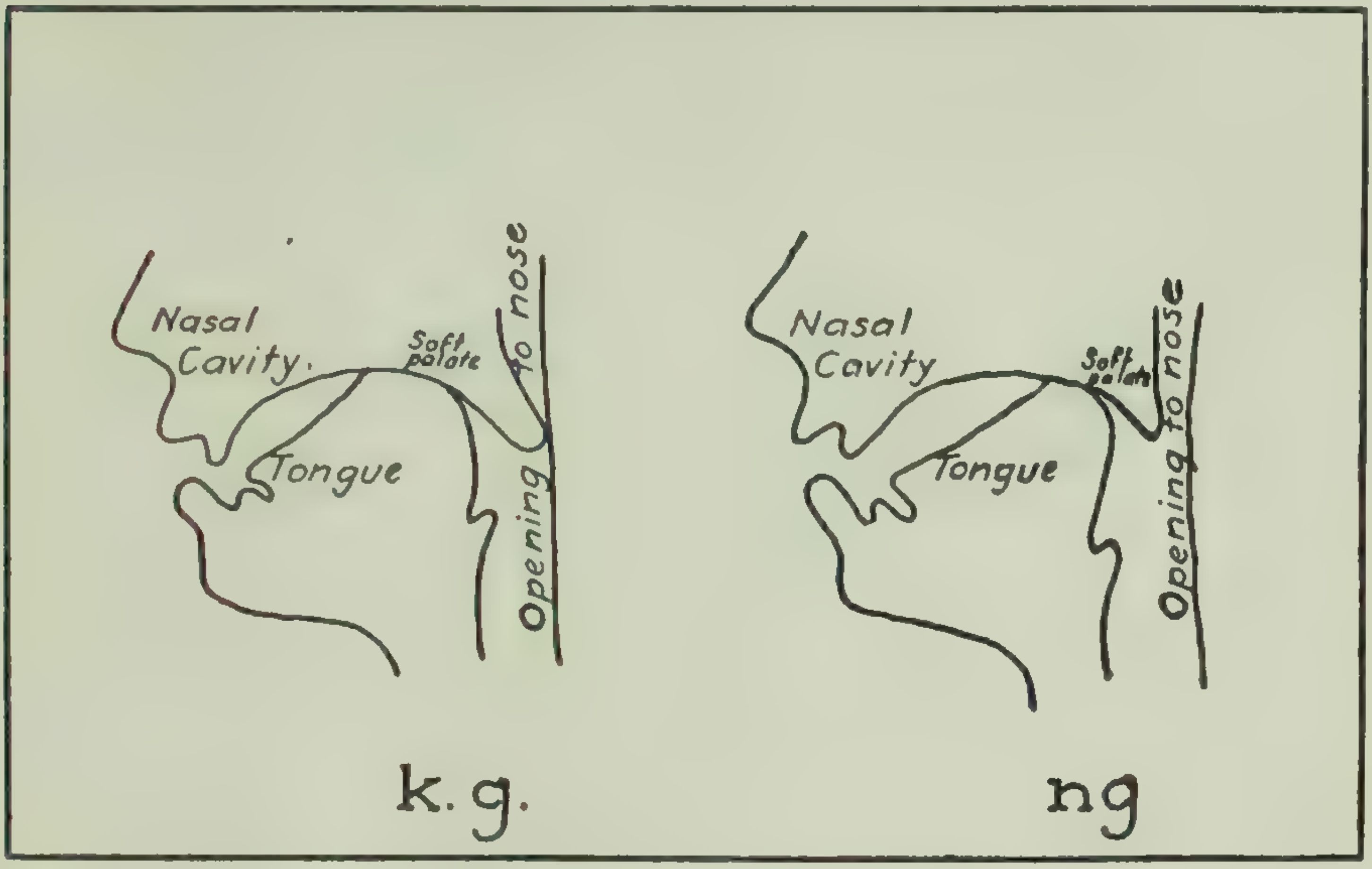


FIG. 125. DIAGRAMMATIC REPRESENTATION OF THE DIFFERENCE IN THE ARTICULATION OF CERTAIN SOUNDS

(From an Americanization pamphlet, issued by the California State Board of Education.)

Location picture graphs. Figure 126 diagrammatically represents the location of the ductless glands in the human body. No special effort is made to show their exact position or size, but their approximate positions are sufficiently indicated for popular purposes. The recent scientific findings concerning the ductless glands and their relation to well-being have attracted wide-spread interest. The book by Dr. Harrow, from which this sketch is reproduced, is an effort to bring this knowledge to non-technical readers.

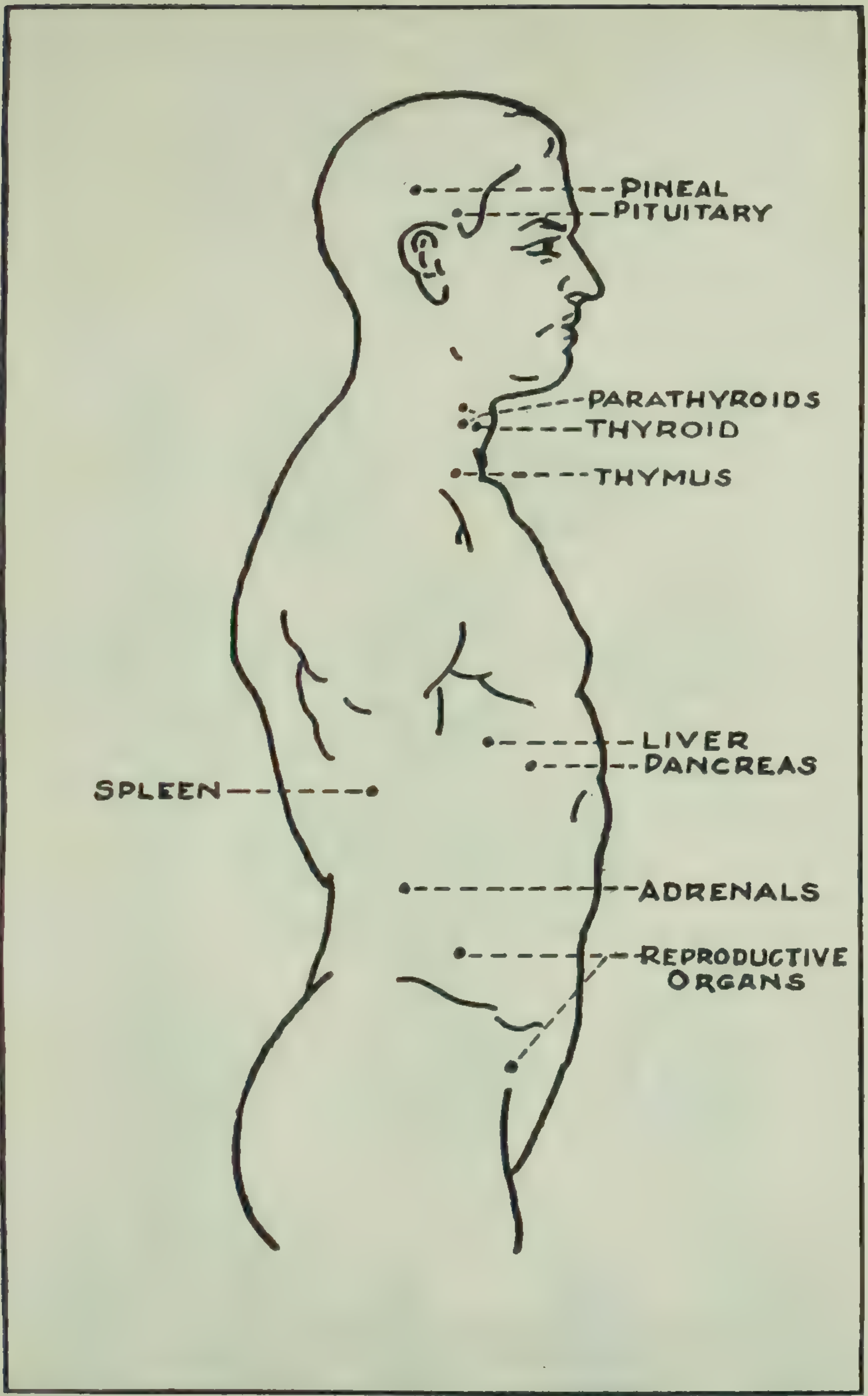


FIG. 126. DIAGRAMMATIC SKETCH, SHOWING LOCATION OF DUCTLESS GLANDS IN THE HUMAN BODY

(From *Glands in Health and Disease*, by Benjamin Harrow.)

Figure 127 is taken from an advertisement printed on blotters and distributed by a publishing house. It is intended to convey the value of a certain series of textbooks. The children, in silhouette form, are represented as being engaged in target practice, aiming at the center of a number of good purposes, the largest and by inference the most important of which is "clear thinking." It is evident that they are good marksmen, for a large number of hits are recorded.

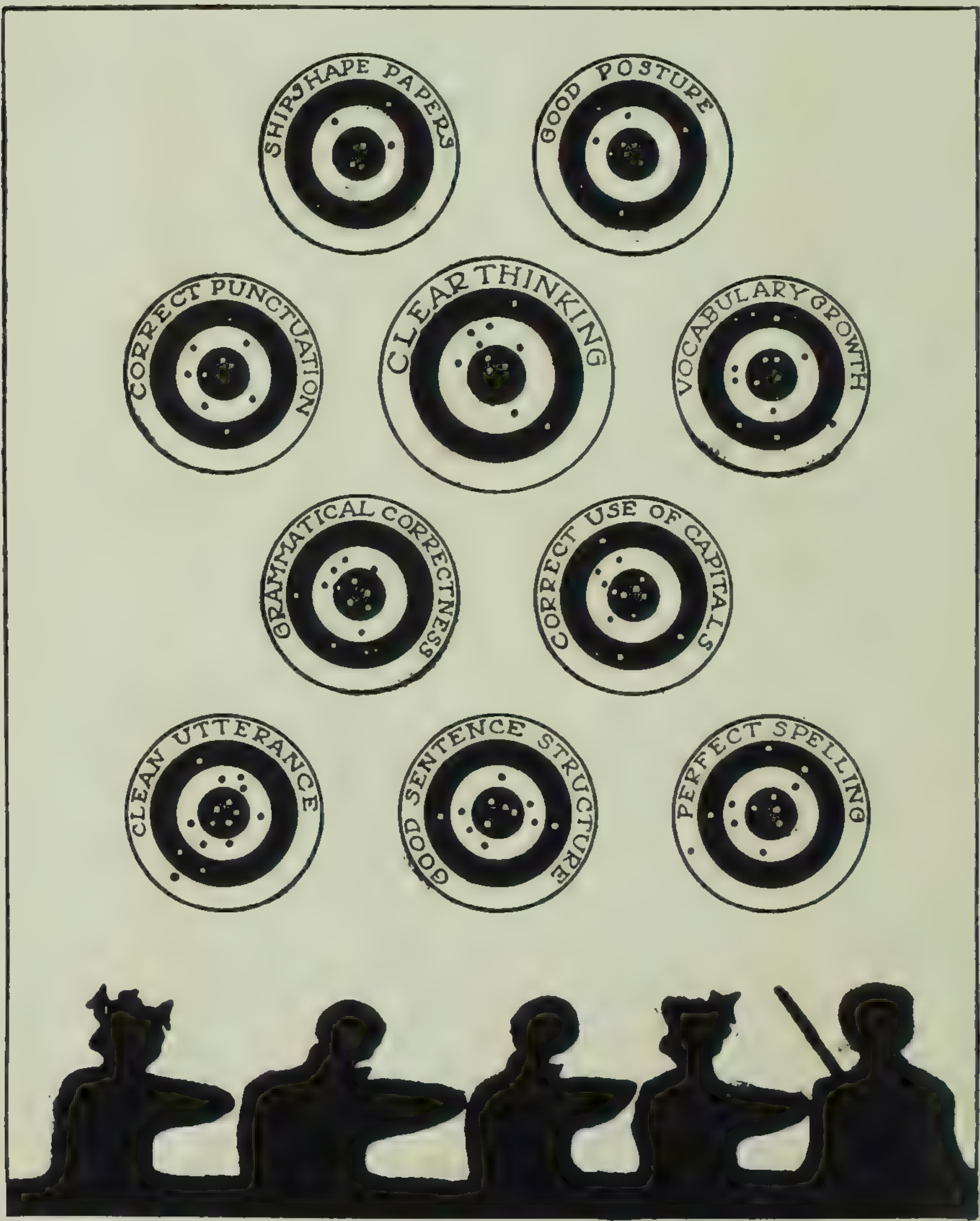


FIG. 127. CHART USED IN ADVERTISING SELF-HELP ENGLISH LESSONS BY WORLD BOOK COMPANY

Figure 128 is a combination two way horizontal bar and pictorial chart. The vertical zero lines are spread apart, and between them are inserted pictures representing the three items which constitute the subjects of comparison. This chart has been used extensively in advertising.

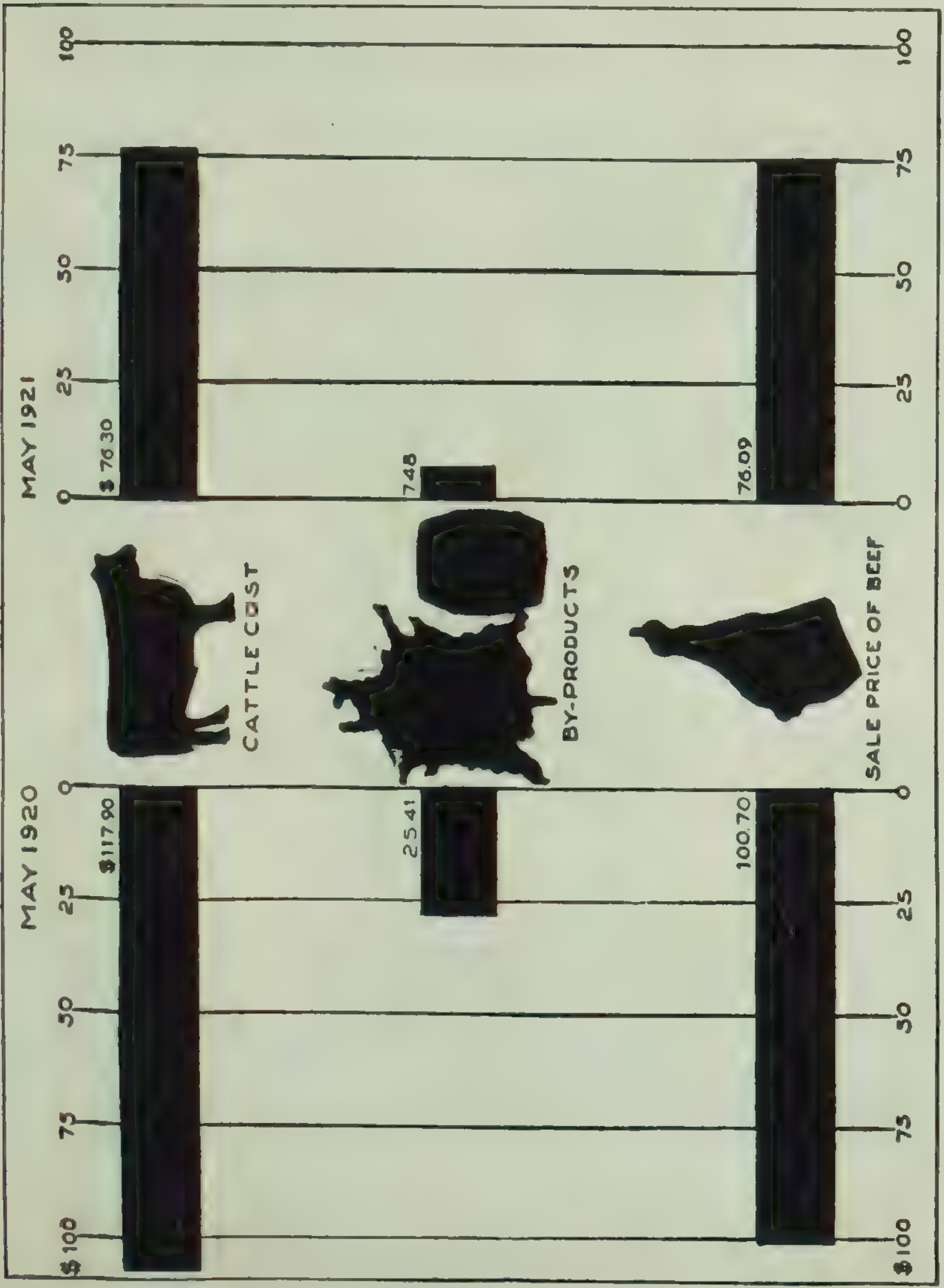


FIG. 128. CHANGES IN MEAT PRICES, 1920–21
(From an advertisement by Swift & Co.)

Posters. Figure 129 shows how pictorial methods may be made by school children, in poster style, to convey important ideas. There are some children in every school who can do such work. The making of the posters and the selection of suitable wording have high instructional value. The contest for which these posters were made aroused the interest of thousands of school children. Similar contests have been successfully conducted for posters to be used in campaigns for school bonds.

FIG. 129. POSTER MADE BY CHILDREN IN LOS ANGELES ELEMENTARY SCHOOLS FOR A "SAFETY FIRST" CONTEST CONDUCTED BY THE AUTOMOBILE CLUB OF SOUTHERN CALIFORNIA

(From *The Los Angeles Times.*)

Comparative-size graphs. Figure 130 conveys an idea of the size of the "Aquitania," a modern steamship, by showing how it could contain the entire Capitol building in Washington, and have enough room left over for several state capitol buildings. The main purpose is to give an impression of magnitude, without much regard for exact measurement. It is well known that the Capitol is an enormous building, and the knowledge that the "Aquitania" is so much larger occasions surprise and interest.

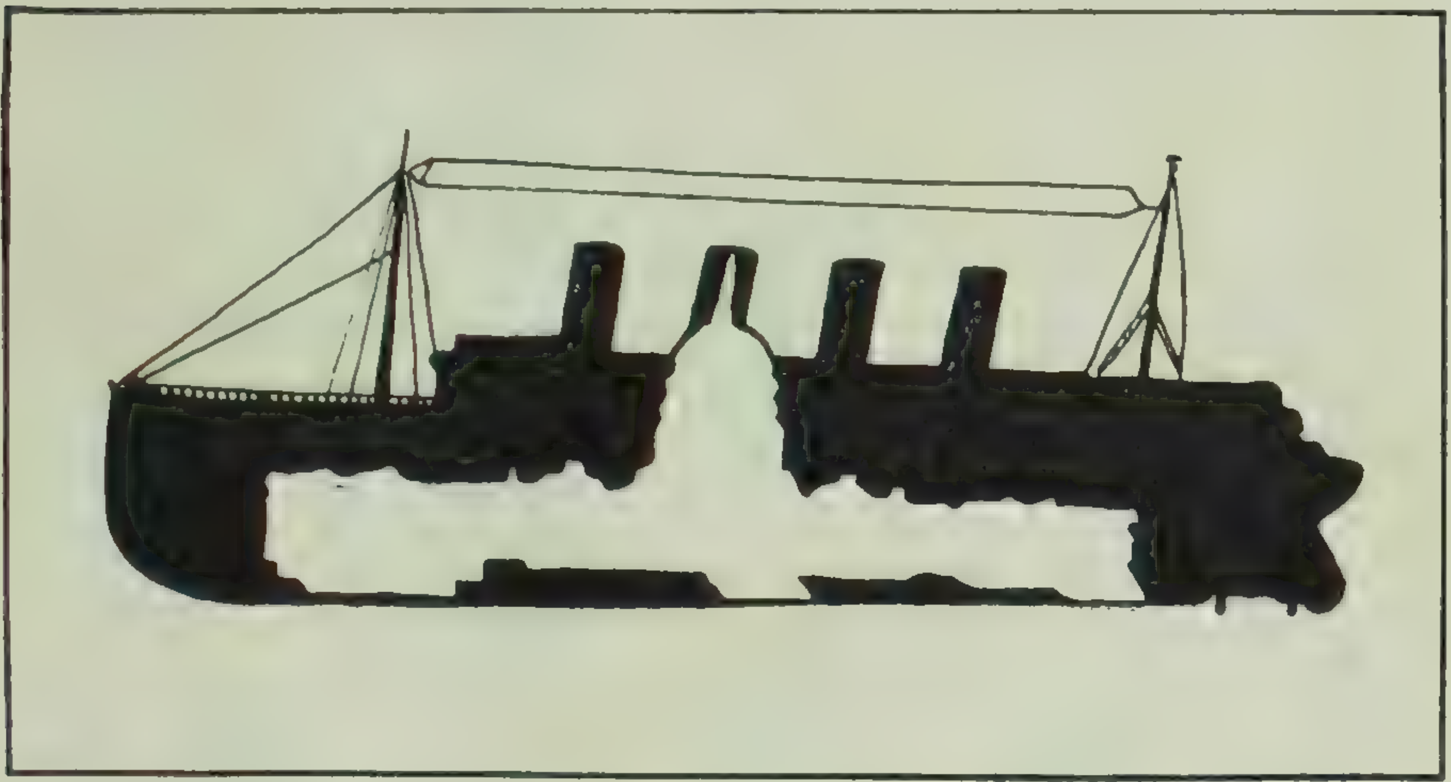


Fig. 130. Sketch Showing Comparative Size of the World's Largest Steamship, the *Aquitania*, and the United States Capitol Building at Washington

(Drawn from superimposed photographs.)

Hereditary transmission graphs. Figure 131 shows the hereditary transmission of the characteristic traits of the "waltzing mouse," an animal which has been made the subject of psychological investigation. The condition is recessive, being transmitted in the same manner as mental deficiency (see Figure 111). The use of the pictures adds considerably to the interest of the presentation. In repeating a pictorial figure many times in a single chart, it is best to make the drawings with a single stencil or pattern, so that uniformity may be maintained. No original drawing need be done in such a chart, once a suitable figure has been found for making the stencil. In this case the outline of the mouse was cut out of cardboard, traced with a pencil and inked in. For special emphasis, the "waltzing" mice might have been made in black and the ordinary mice in white. It happens, however, that the trait under consideration is recessive, and is due to the *absence* of the determiner for normality; hence the adopted manner of shading.

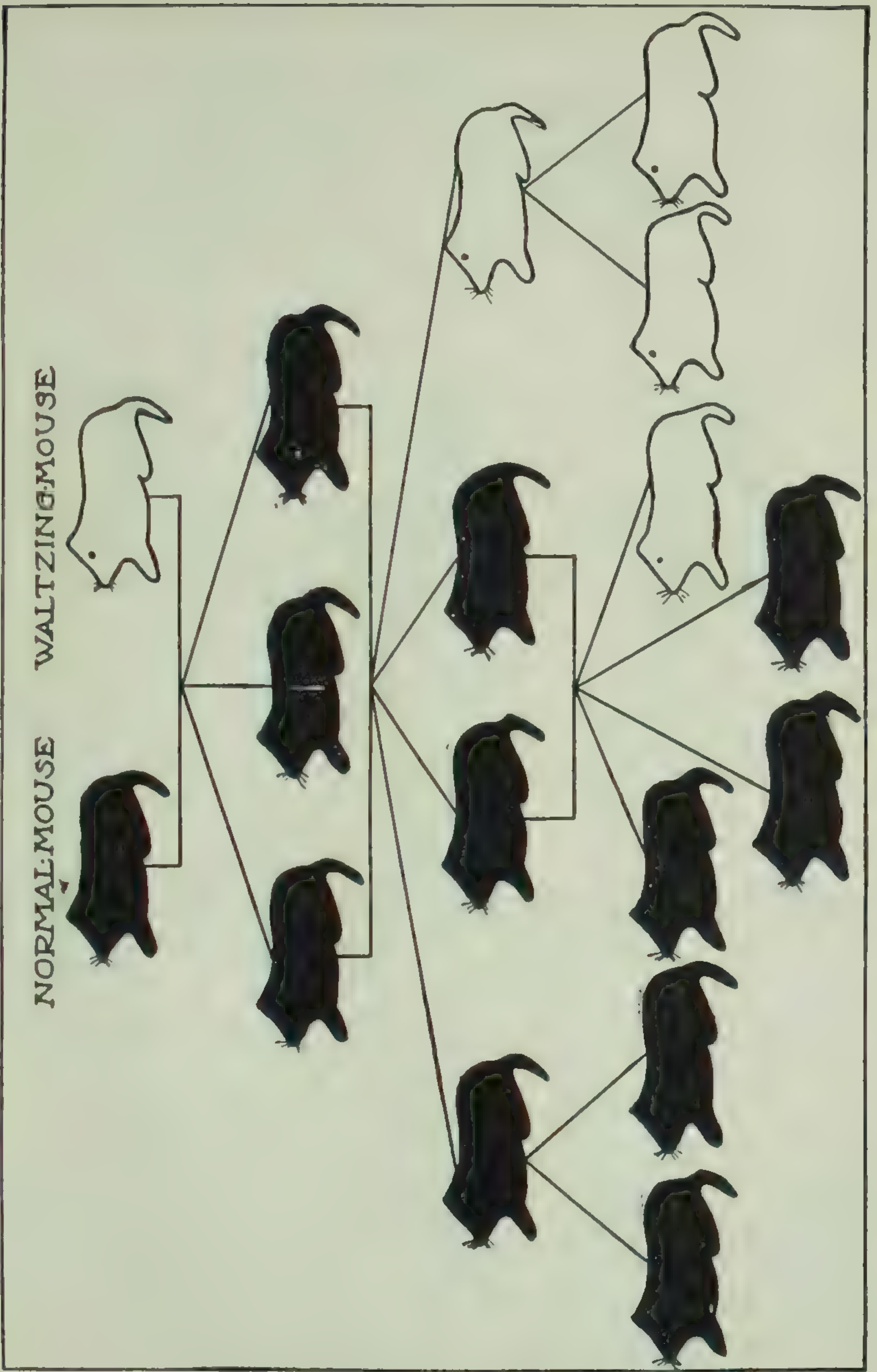


FIG. 131. MENDELIAN INHERITANCE IN MICE
(From *Social Evolution*, by F. Stuart Chapin.)

Desirable and undesirable conditions charts. Figure 132 illustrates the use of pictorial comparison in newspaper statistical presentation. Although this method is subject to limitations which have been brought out in previous discussion relative to the comparison of irregular shapes, the chart has the advantage of arresting the attention of persons who would not be interested in mere statistical tables. The use of exact data in connection with the explanatory caption lessens the danger of erroneous conception.

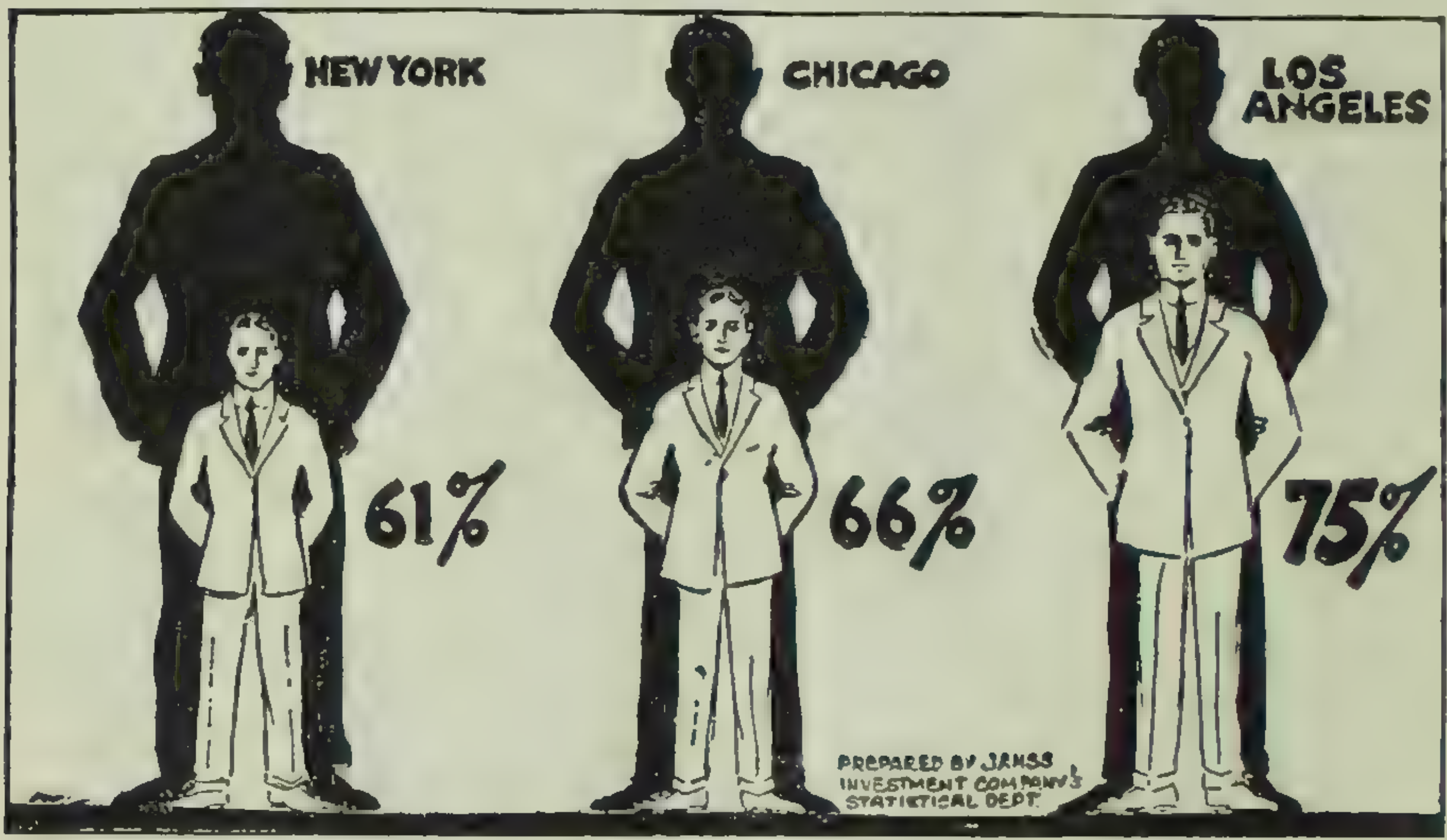


FIG. 132. NEWSPAPER CHART, SHOWING PROPORTION OF NATIVE-BORN POPULATION IN THREE CITIES

Shadow in rear represents total population, white figures indicate percentage ratio of native-born. (From *The Los Angeles Times.*)

Figure 133 is illustrative of the many charts being used by progressive departments of public health for popular education. In this case a pictorial comparison is drawn between undesirable and desirable conditions of interest to the general public. The upper picture is suggestive of disorder, disease, and degeneracy, costing millions of dollars from public funds. Below is a pleasing, orderly scene, depicting the more constructive and hopeful side of human welfare work.

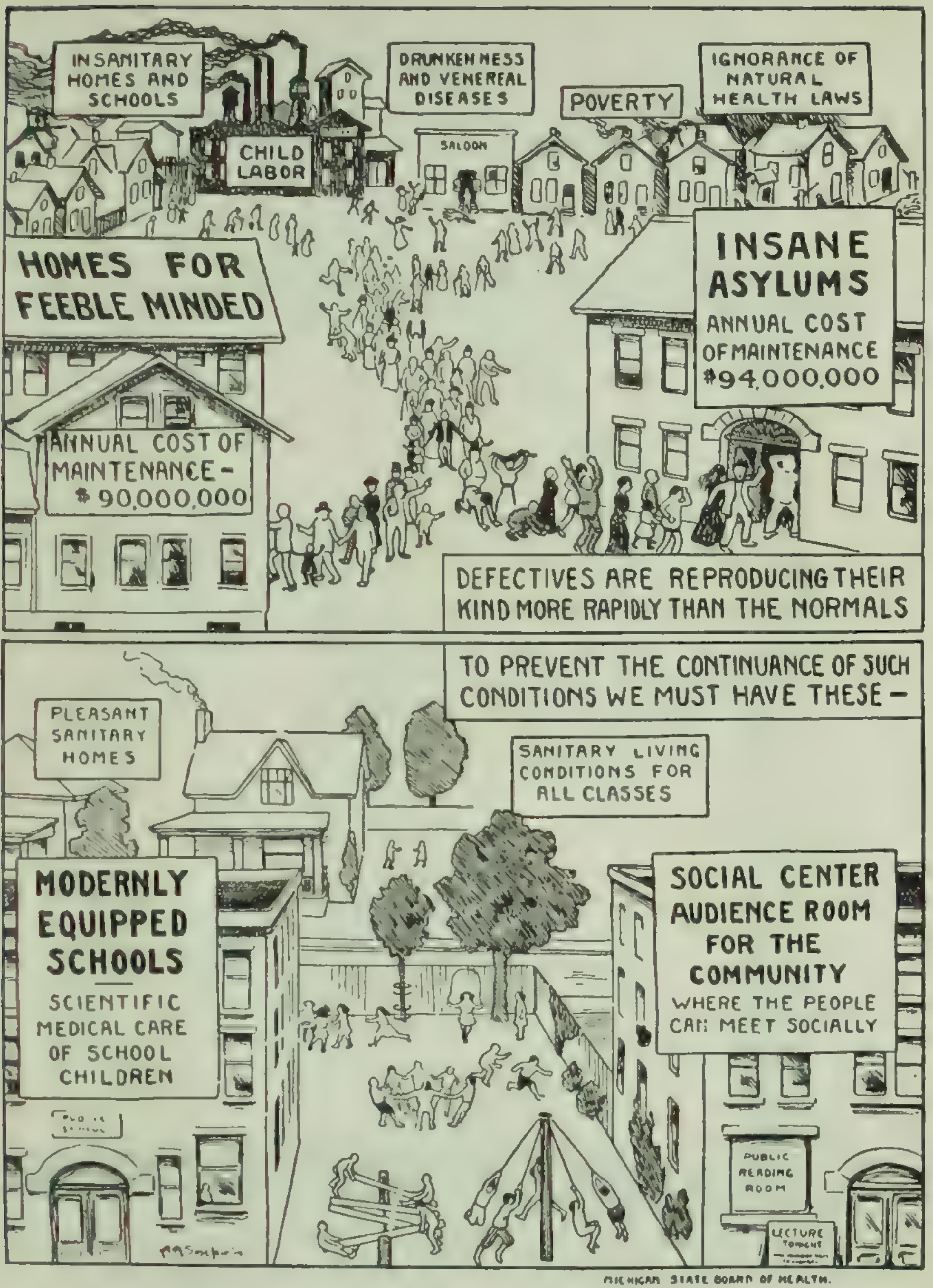


FIG. 133. PICTURE CHART, USED IN EDUCATIONAL CAMPAIGNS BY THE MICHIGAN STATE BOARD OF HEALTH

(From *Public Health*, Lansing, Michigan.)

Pictures and cartoons. Figure 134 is a grewsome picture-graph with a lettered query which automatically brings the desired reply. This illustrates how a simple picture may arouse strong feelings, and how easily a definite attitude can be elicited without the use of lengthy argument.

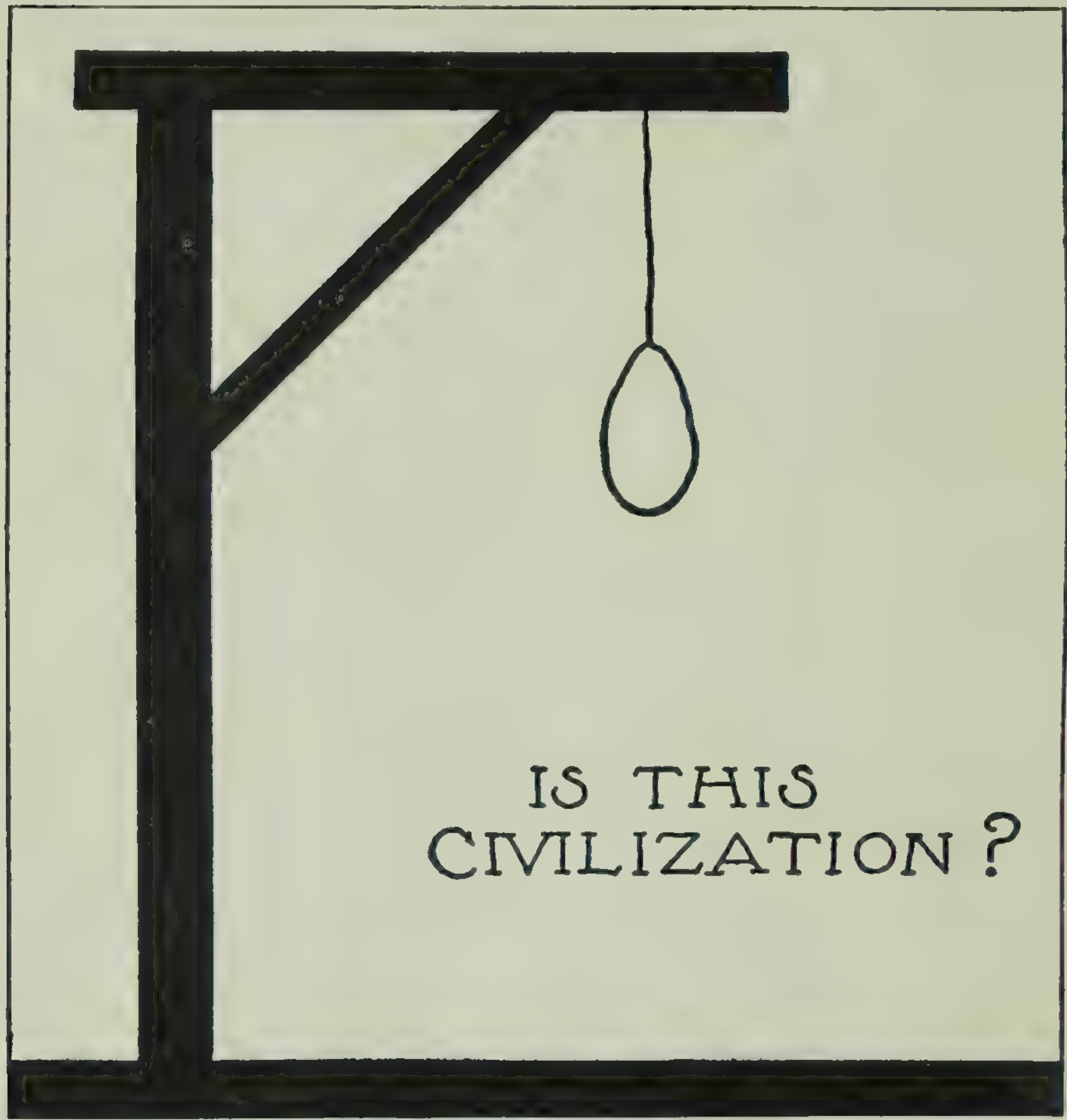


FIG. 134. POSTER CHART, INTENDED TO AROUSE PUBLIC INDIGNATION DURING A CAMPAIGN SEEKING TO ABOLISH CAPITAL PUNISHMENT

PROBLEMS FOR CHARTING

1. Redraw the chart of the English school system (Figure 96) in the form of a tree, branching out at the different age levels. This will be a marked contrast to the "educational ladder" of Professor Cubberley (Figure 119), but the principle of illustration will be brought out.
2. Obtain current data from Government reports concerning infant mortality. Construct a thermometer, on the plan of Figure 120, arranging the countries according to their new positions. Some important shifting will be observed.
3. Make a drawing of some fruit or vegetable (apple, banana, carrot, potato) showing the analysis of content, as in Figure 122. The data may be obtained from any good textbook relating to foods.
4. Following the plan of Figure 123, make a sketch-height comparison of several world-famous structures; Eiffel tower, Woolworth building, Washington monument, the leaning tower of Pisa, etc. The sketches need not be complete or correct in detail, excepting for the height representation.
5. Following the plan of Figure 128, make a comparative horizontal-bar chart referring to production statistics of several products which can be represented by appropriate drawings (corn, wheat, cotton, oil, hogs, cattle, etc.).
6. Work out a number of designs and wording for posters suitable for school children, as in Figure 129.
7. Make a silhouette pictorial chart illustrating the number of children per drinking fountain in your school. The children may be represented by a figure, duplicated as many times as necessary, in row formation on one side of the fountain; or the number of children for each two fountains may be shown.
8. Make a pictorial inheritance chart showing the transmission of mental deficiency according to the Mendelian laws, as in Figure 111; but use human figures, made with stencils as described for Figure 131.

CHAPTER XV

VERBAL-DISPLAY CHARTS

(Explaining Figures 135 to 139, Inclusive)

General definition. This chapter deals with charts which are mainly verbal in character. Their purpose is not to show areas, lengths, and numbers, but to present to the reader a message of words. In some cases, as will be seen from the illustrative charts, use is made of non-verbal matter in connection with the message; but structurally such charts are mainly jobs of lettering and the appropriate placing of the words on the assigned area.

Budget charts. Figure 135 is redrawn from a chart made up of data collected by a governmental agency, relative to the cost of living and the distribution of income. Its appeal is chiefly popular, although the percentages are shown according to the correct method for presenting circular segments, as explained in Chapter V. Note particularly the use of the display caption encased in an extra space around the circle. Such addition of verbal matter would not be called for in the technical use of the data, but has an appeal for the average reader, who might otherwise pass the chart by without undertaking to read or interpret it.

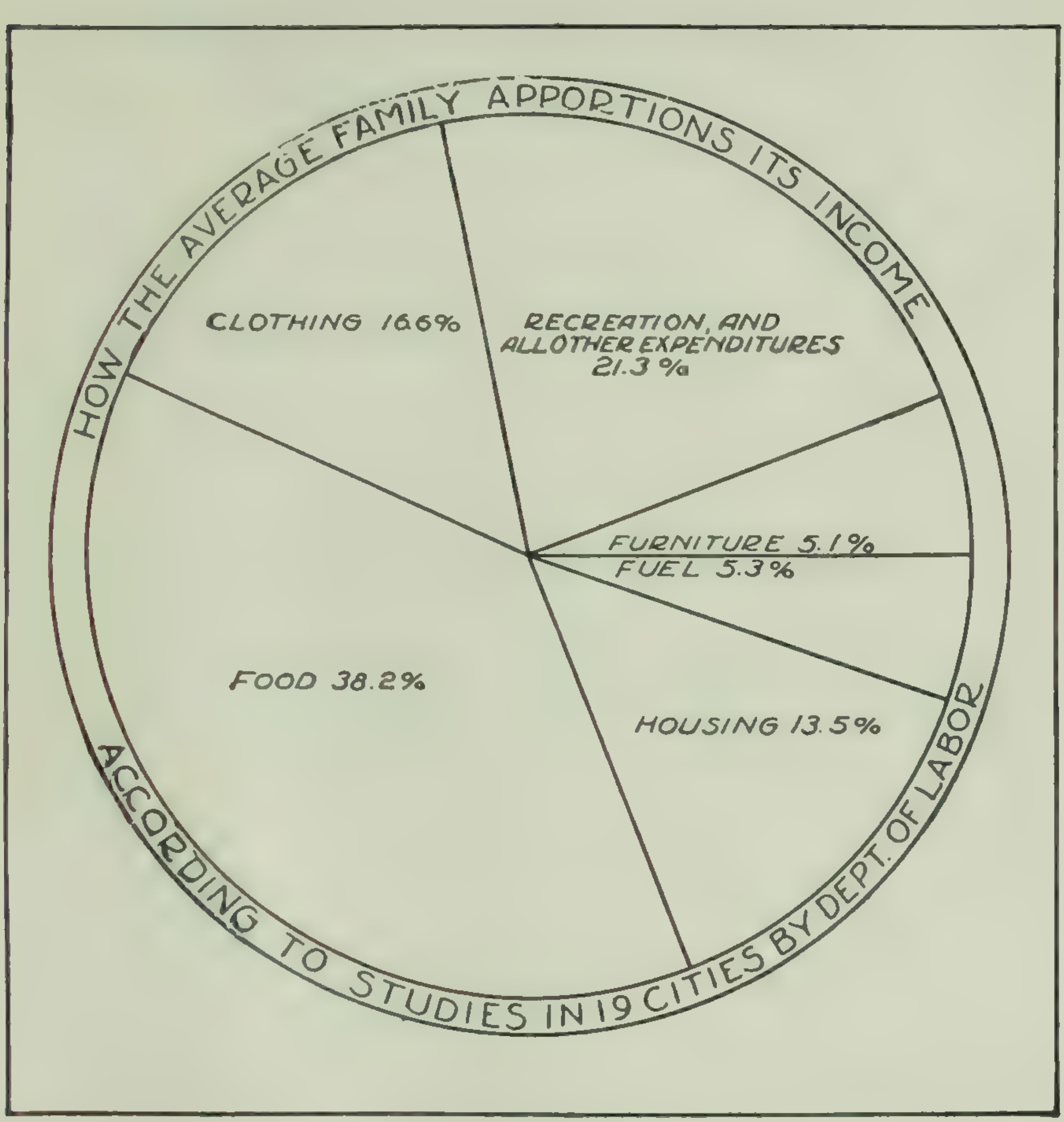


FIG. 135. VERBAL-GRAPHIC CHART, SHOWING DIVISION AND EXPENDITURE OF INCOME

Based on data collected by United States Department of Labor. (From *The Literary Digest.*)

The school-program chart. Figure 136 is a combination verbal and graphic presentation of an answer to the question "What do you do with your boys?" often propounded to Superintendent Nelles, of the Whittier State School. The main purpose of the institution is to provide what has been called "twenty-four-hour education"; that is, a system of continuous supervision in which a satisfactory division is made of time in the interest of general development and vocational training. The rim of the circle contains numerals representing the twenty-four hours of the day, with noon at the top and midnight at the bottom. The segments of the circle are laid off according to the period of time devoted to each of the several purposes, and each is given appropriate verbal explanation. The sleep period is emphasized by thin single hatching. This is an important emphasis, because the fact of sufficient sleep, under proper supervision, stands out in marked contrast to the usual employment of this period in the previous history of social maladjustment. The large lettering at the top and bottom contains short, easily memorized phrases which have value for the popular presentation of such a chart. The plan of this chart may be adapted to many uses in explanation by public service agencies of the nature and scope of their work.

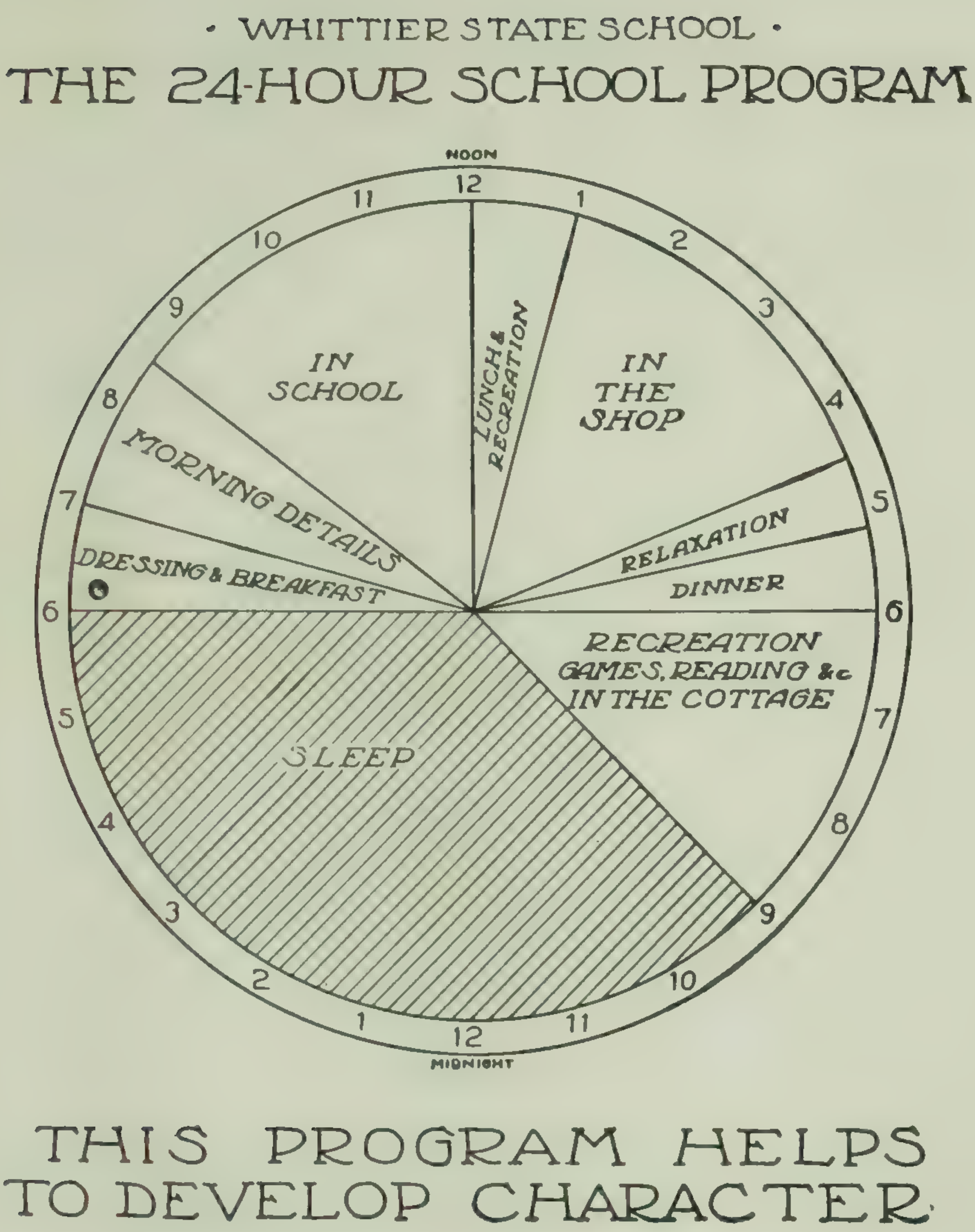


FIG. 136. POSTER CHART, SHOWING CONTINUOUS SUPERVISION OF WHITTIER STATE SCHOOL

Institutional data charts. Figure 137 is a graphic-verbal presentation of institution data of a more technical character, but of importance to the general public. The state hospitals deal with a wide range of nervous and mental disorder, the percentages of which, shown on this chart, are fairly typical. Note the use of the verbal captions *outside* of the circle, with arrow indicators pointing inward. This plan allows for large lettering, and has a more popular appeal than the usual lettering inside the segments. In such charts it is just as important that the percentage segments be measured correctly as would be the case in a chart made up for technical use. Accuracy and attention to detail are always essential.

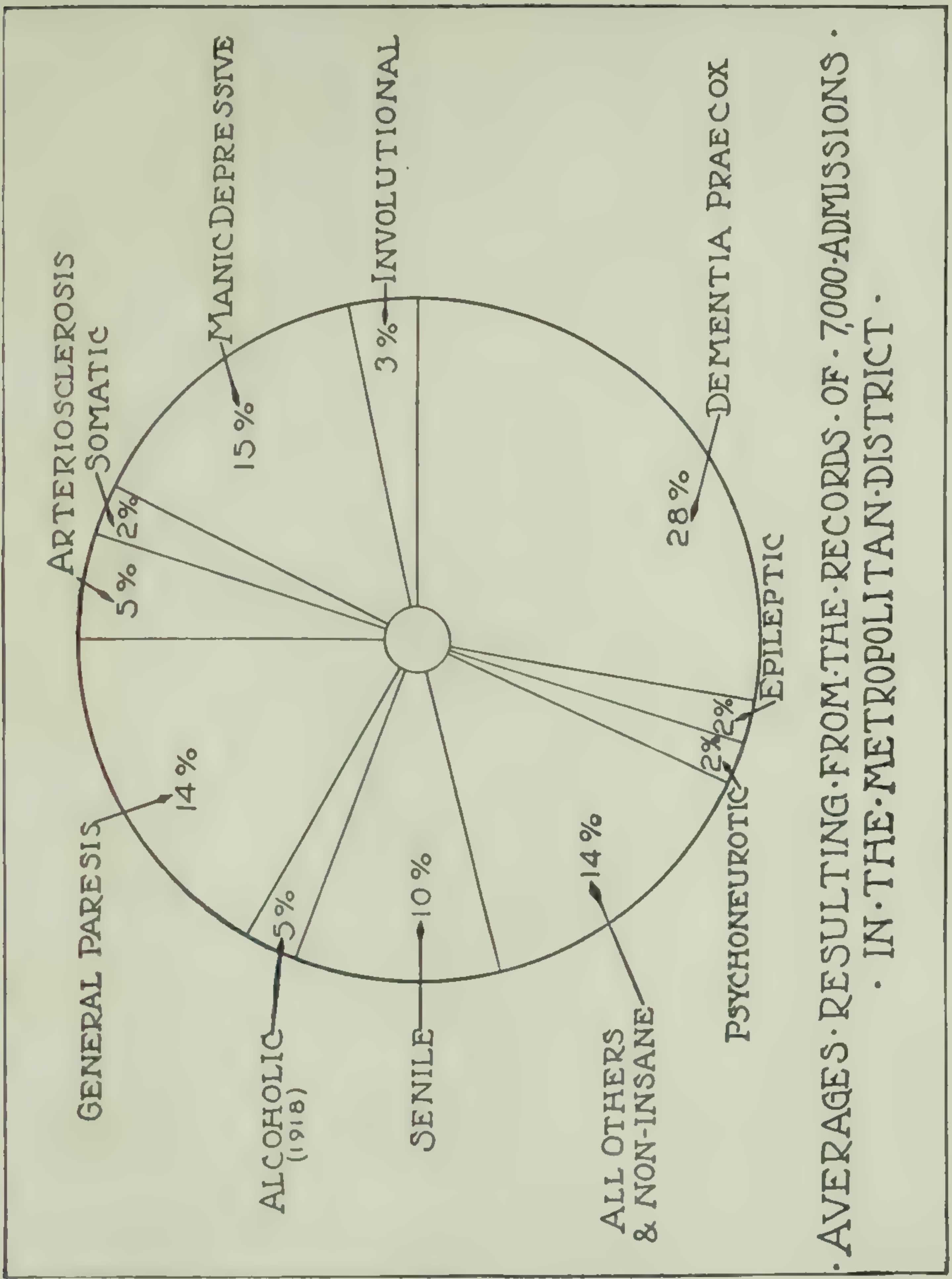


FIG. 137. PROPORTIONAL CLASSIFICATION OF MENTAL DISEASES IN NEW YORK STATE HOSPITALS

(From *State Hospital Quarterly*, November, 1922.)

Verbal-message charts. Figure 138 is a verbal message using, for graphic appeal, a clock represented as ticking off the millions of dollars spent for the World War. What this money would do if devoted to constructive educational purposes is brought out with startling emphasis in the wording below. Note that each hour on the face of the clock represents the expenditure of ten millions of dollars, while one revolution of the hour hand represents 240 millions.

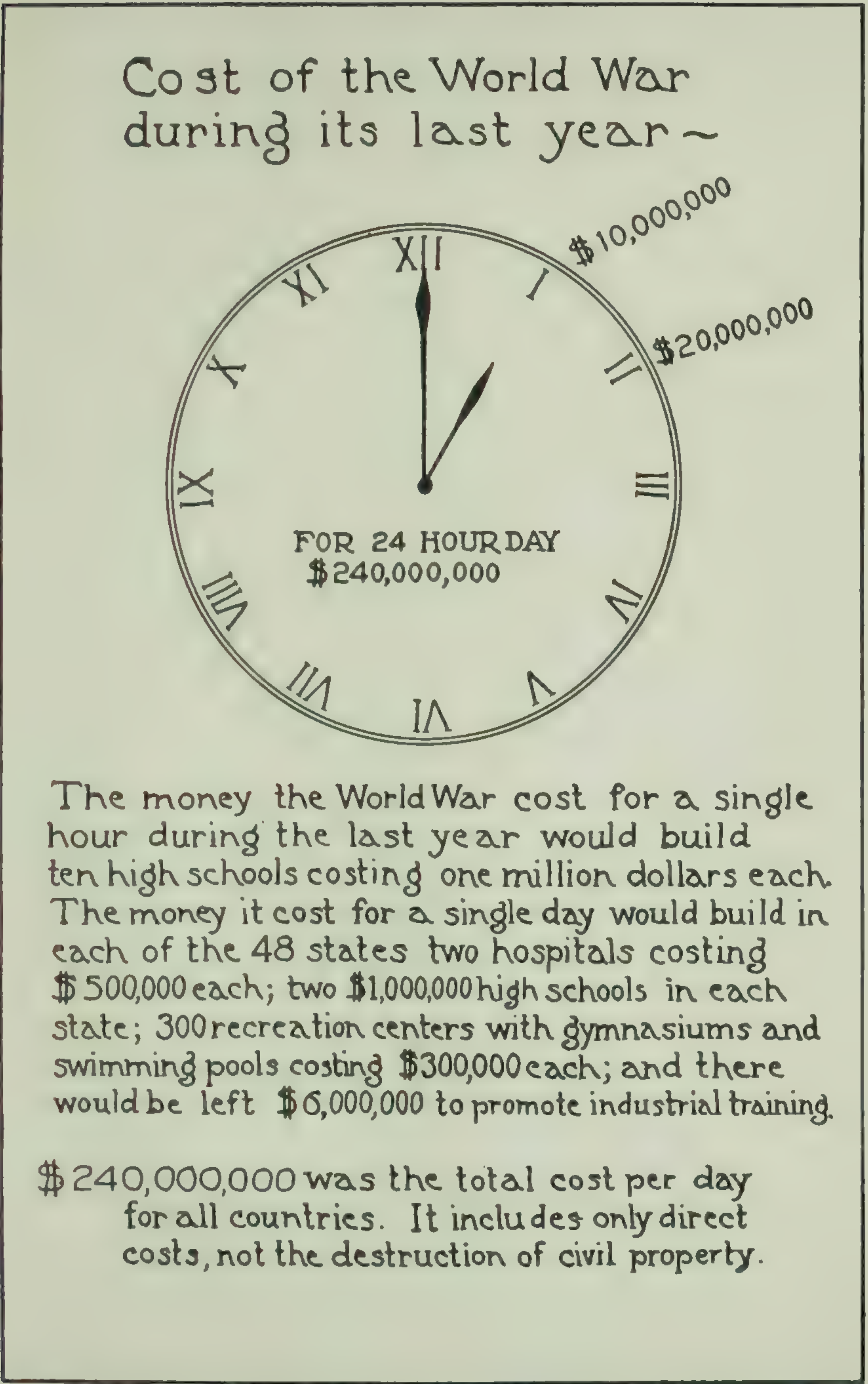


FIG. 138. VERBAL CHART RELATING TO EXPENDITURES IN THE WORLD WAR AND WHAT AN EQUIVALENT EXPENDITURE WOULD DO FOR EDUCATION
(From *The Next War*, by Will Irwin.)

Figure 139 is an exclusively verbal message, with a single small ornament for effect. The statements are based on an actual study of consolidated rural schools, and are suitable for a poster to be used where such a message is desired. This plan can be adapted to a great many practical purposes in acquainting the public with educational needs and achievements.

Charts of this type are based on the same principles as advertising, and are subject to the same laws. It is important, first, to secure the attention of the reader; second, to cause him to remember as much as possible of the message. Following is a summary of a chapter on memory from a book on advertising:

In general, it may be said that three things concerning the objects used in the advertisement should be kept in mind. In the first place, not all facts or objects have an equal chance of being remembered. Consequently, those things which have a relatively high memory value should be employed. In the second place, the way in which the object is experienced determines its memorability, for the way in which it is presented determines the type of change which is made in the nervous system. Certain ways of presenting the same material, consequently, are much more effective than certain other ways. Repeating the same advertisement, time after time, will give increased memory value; increasing the size of the advertisement will still further improve the memory value; and presenting the same appeal in different ways on successive occasions is still more effective. A rhythmic form of presentation is preferable to one which is non-rhythmic. In the third place, any fact which is once known will, in course of time, be forgotten. It is therefore necessary that the public be reminded from time to time. (From *Advertising and its Mental Laws*, by H. F. Adams.)

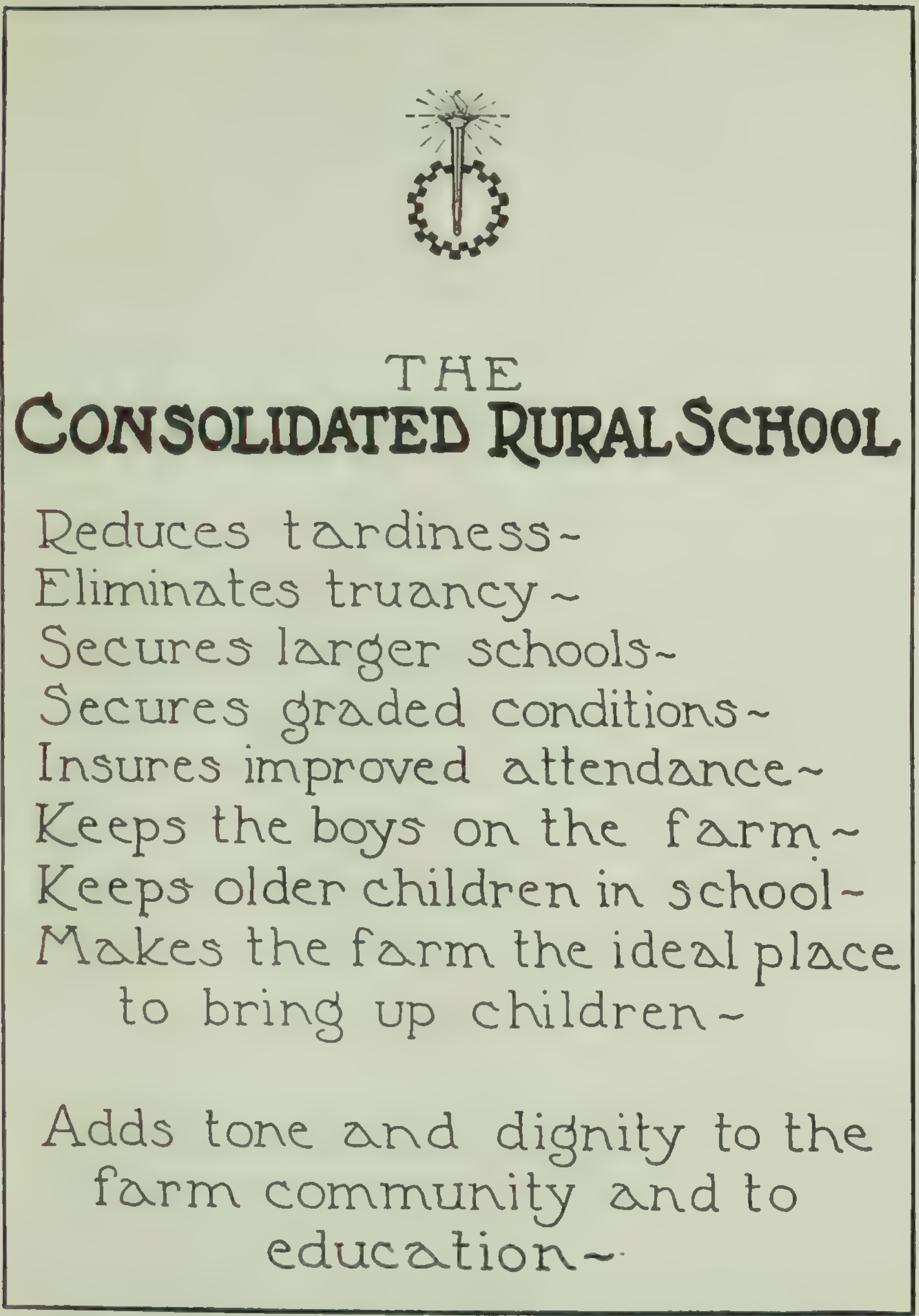


FIG. 139. POSTER CHART BASED ON A STUDY OF RURAL SCHOOLS IN OHIO

PROBLEMS FOR CHARTING

1. Make a verbal-display chart from data on public expenditures of a community, emphasizing the relative amount spent for education, and other purposes of less importance. Make use of caption material similar to that shown in Figure 135.
2. Show how the day or week is spent by a public school with which you are familiar. Make up a chart patterned after Figure 136, having in mind its suitability for use as a poster for popular exhibition or local newspaper publication.
3. Make up a chart, patterned after Figure 136, to show a proposed daily schedule of twenty-four hours for a normal growing boy of about twelve years. Include school, play, sleep, and other activities you deem important to emphasize.
4. Draw a chart, patterned after Figure 137, showing the racial and nationality groups represented in a school having a mixed group of pupils.
5. Make up a verbal display chart, similar to Figure 139, showing the following platform of the National Education Association:

   A competent teacher in every school.
   Increased facilities for teacher training.
   The professionalization of teaching.
   The investigation of educational problems.
   A National Department of Education.
   Unification of national educational forces.
   Active help to local associations.
   Equal pay for equal service.
   Coöperation with public welfare organizations.
   Service: to teachers, the public, and the children of the nation.

6. Make a verbal display chart from the following quotation:

   Strong people demand education and create opportunity. A good citizen is a man who can take care of himself and have something left over for the common welfare. — David Starr Jordan.

CHAPTER XVI

CHARTS MADE WITH THE AID OF TYPE

(Explaining Figures 140 to 146, Inclusive)

General definition. It is sometimes desirable to make charts on the typewriter or to use the typewriter or printer's type for lettering. Although such charts are not so clearly reproduced as those made with India ink, they may serve a useful purpose, especially when the materials for drawing or lettering are not readily available.

Typewriter work. Figure 140 was made entirely on the typewriter. It represents a statistical table, to which there is added a series of horizontal bars in the individual frequency formation discussed in Chapter VIII. Each asterisk represents one case, referring to the frequency column which is third from the left. It would have been better to have put the frequency column in the last place on the right, so that it would be next to the bars. The order shown is apt to be confusing to the reader. Note that the numerical data are complete, including the median and percentile locations. In making such charts for reproduction it is important to use a good black typewriter ribbon, and to be sure that all numerals and letters are clean so that they will show plainly and clear.

Figure 141 was also made entirely on the typewriter, and represents a vertical bar individual-frequency distribution, differentiated to show three groups of pupils. The numerals below the base line represent mental ages, ranging from 3 years 10 months to 9 years 8 months, reading from left to right. The years are underscored. The columns represent intervals of two months of mental age; that is, six columns for each year. The number and percentage of cases for each group are shown in the table at the top. In making this chart it was necessary for the typist to insert the paper in two positions, as the columns were made horizontally. The slightly irregular spacing between some of the columns is due to an attempt to center each row on the appropriate number below the base line. The figure 10 takes up two full spaces.

GRAPHIC DISTRIBUTION CHART NO. 7

INSTITUTION: Public Schools # 32, # 34 TESTED: December, 1922.
GROUP: 7 B Classes EXAMINER: Bureau of Research
MEASURES IN: Toops Clerical Test

NUMERICAL DISTRIBUTION — GRAPHIC DISTRIBUTION (Each star represents the position of 1 pupil)

Percentile Rank	Sums	Freq.	Score		
.00	0	0	4		
.002	1	1	6	*	
.006	3	2	8	**	
.011	5	2	10	**	
.019	9	4	12	****	
.028	13	4	14	****	
.041	19	6	16	******	
.054	25	6	18	******	
.073	34	9	20	*********	
.095	44	10	22	**********	
.117	54	10	24	**********	
.140	65	11	26	***********	
.168	78	13	28	*************	
.207	96	18	30	******************	
.255	118	22	32	**********************	← 25%ile
.296	148	30	34	******************************	
.387	179	31	36	*******************************	
.462	214	35	38	***********************************	
.544	252	38	40	**************************************	← Median
.618	286	34	42	**********************************	
.687	318	32	44	********************************	
.754	349	31	46	*******************************	
.814	377	28	48	****************************	← 75%ile
.862	399	22	50	**********************	
.898	416	17	52	*****************	
.927	429	13	54	*************	
.946	438	9	56	*** *****	
.961	445	7	58	*******	
.972	450	5	60	*****	
.981	454	4	62	****	
.987	457	3	64	***	
.992	459	2	66	**	
.994	460	1	68	*	
.996	461	1	70	*	
	461		72		
.998	462	1	74	*	
	462		76		
1.000	463	1	78	*	

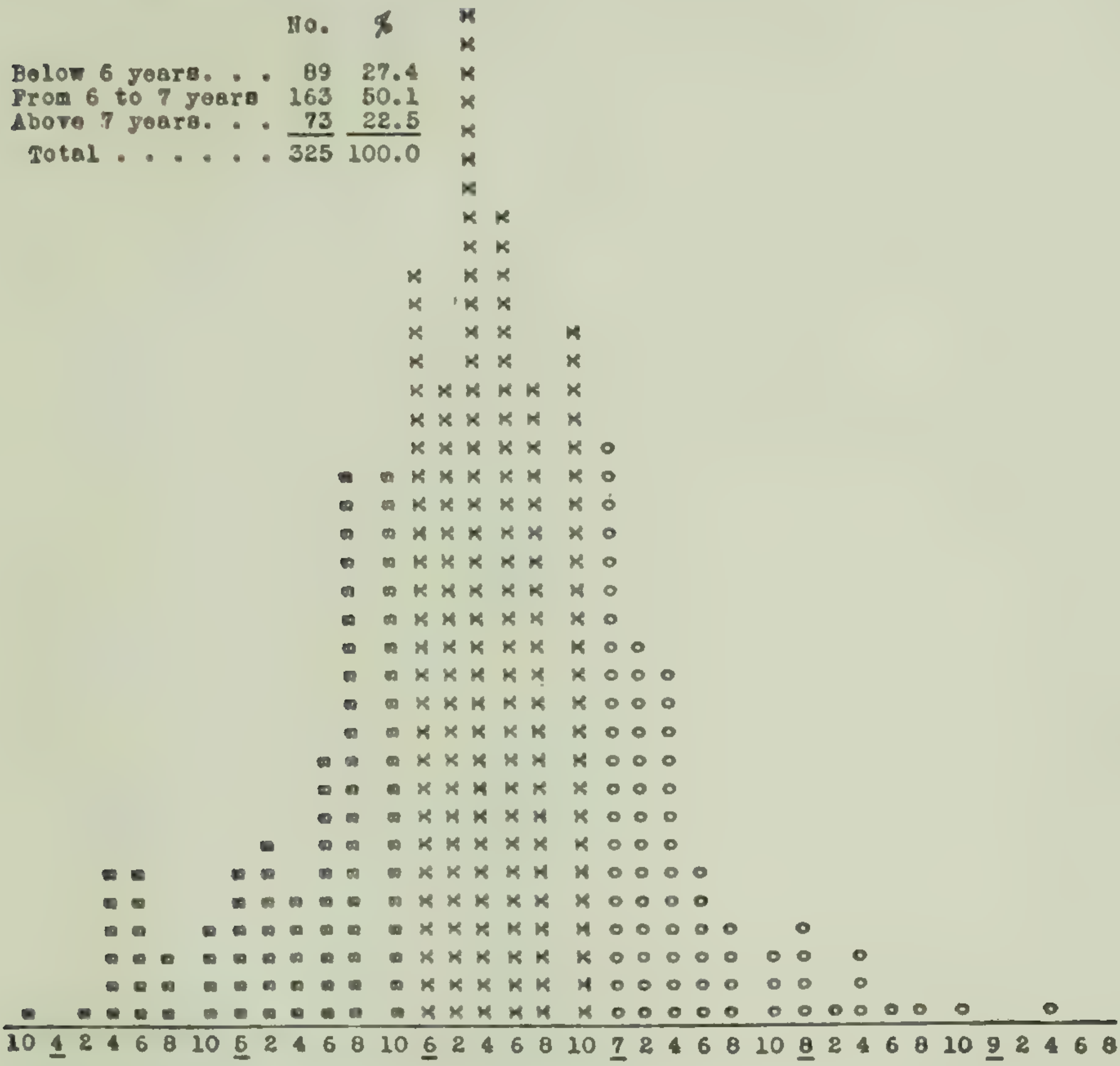
Total Number 463 Median 40.9 Range: (See Freq. Column Above)
25%ile 33.8 Q 7.0 75%ile 47.9

FIG. 140. GRAPHIC DISTRIBUTION TYPEWRITER CHART, SHOWING DISTRIBUTION OF TEST SCORES OF A BALTIMORE SCHOOL

(After J. L. Stenquist, in *The Journal of Educational Research*, December, 1923.)

Mental Ages
Median = 6 years 4 months

	No.	%
Below 6 years. . .	89	27.4
From 6 to 7 years	163	50.1
Above 7 years. . .	73	22.5
Total	325	100.0



Note - Read the table thus: 1 child tested with M.A. 3 years, 10 months, 1 tested 4 years, 2 months, 6 tested 4 years, 4 months, etc.

FIG. 141. VERTICAL COLUMN FREQUENCY-DISTRIBUTION, SHOWING THE RESULTS OF A SERIES OF MENTAL TESTS

The columns are differentiated to show three groups of pupils. (After V. E. Dickson, in a *Report of the Department of Research and Guidance*, Oakland Public Schools.)

A vertical segmented column chart. Figure 142 was lettered on the typewriter, and enclosed in a standard border. Neat hand lettering would look better, but typewriting is often used for the purpose, and is superior to poor hand lettering.

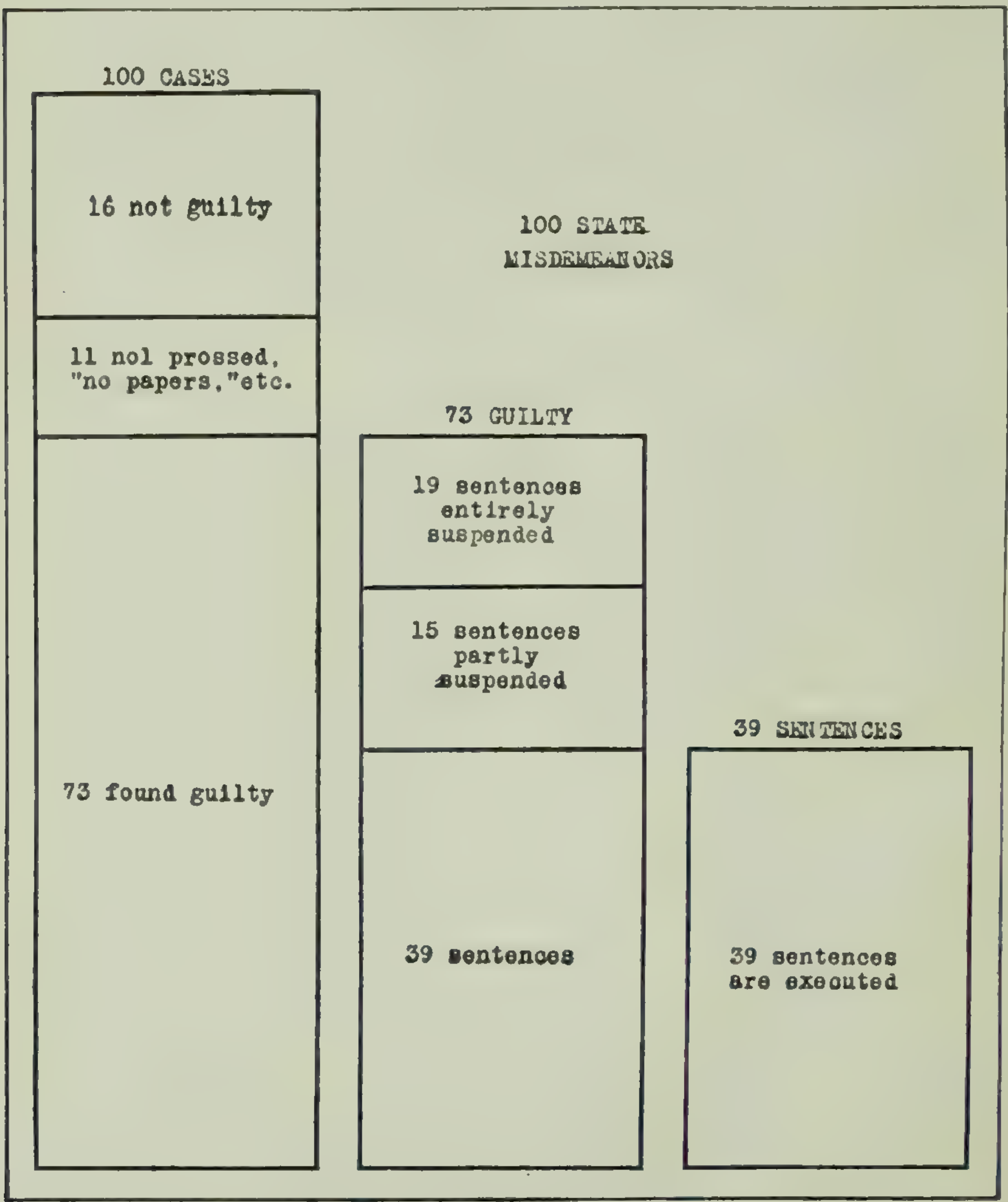


FIG. 142. WHAT HAPPENED TO ONE HUNDRED STATE MISDEMEANOR CASES IN THE CLEVELAND MUNICIPAL COURT, 1919–20.
(From *The Cleveland Survey*, by Raymond Moley.)

Typewriter lettering. Figure 143 was also drawn in ink and lettered on the typewriter, except for the large designating letters, which were made by hand. The combination is effective, but good hand lettering throughout would be more appropriate.

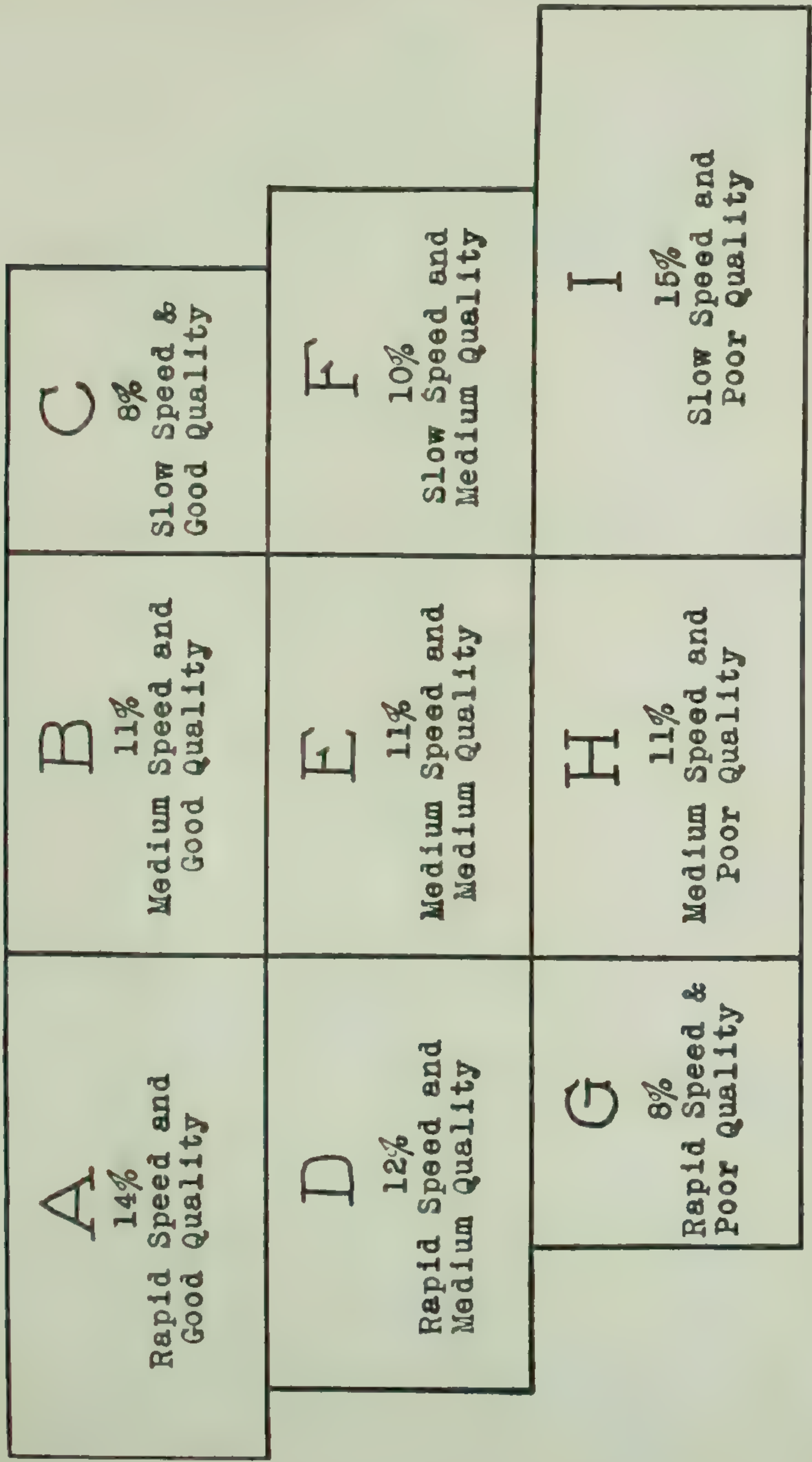


FIG. 143. SHOWING PERCENTAGES OF 1831 CLEVELAND PUBLIC SCHOOL PUPILS, FOUND IN EACH OF NINE GROUPS OF SPEED AND QUALITY IN SILENT READING

(From *Deficiencies in Reading Ability*, by W. S. Gray.)

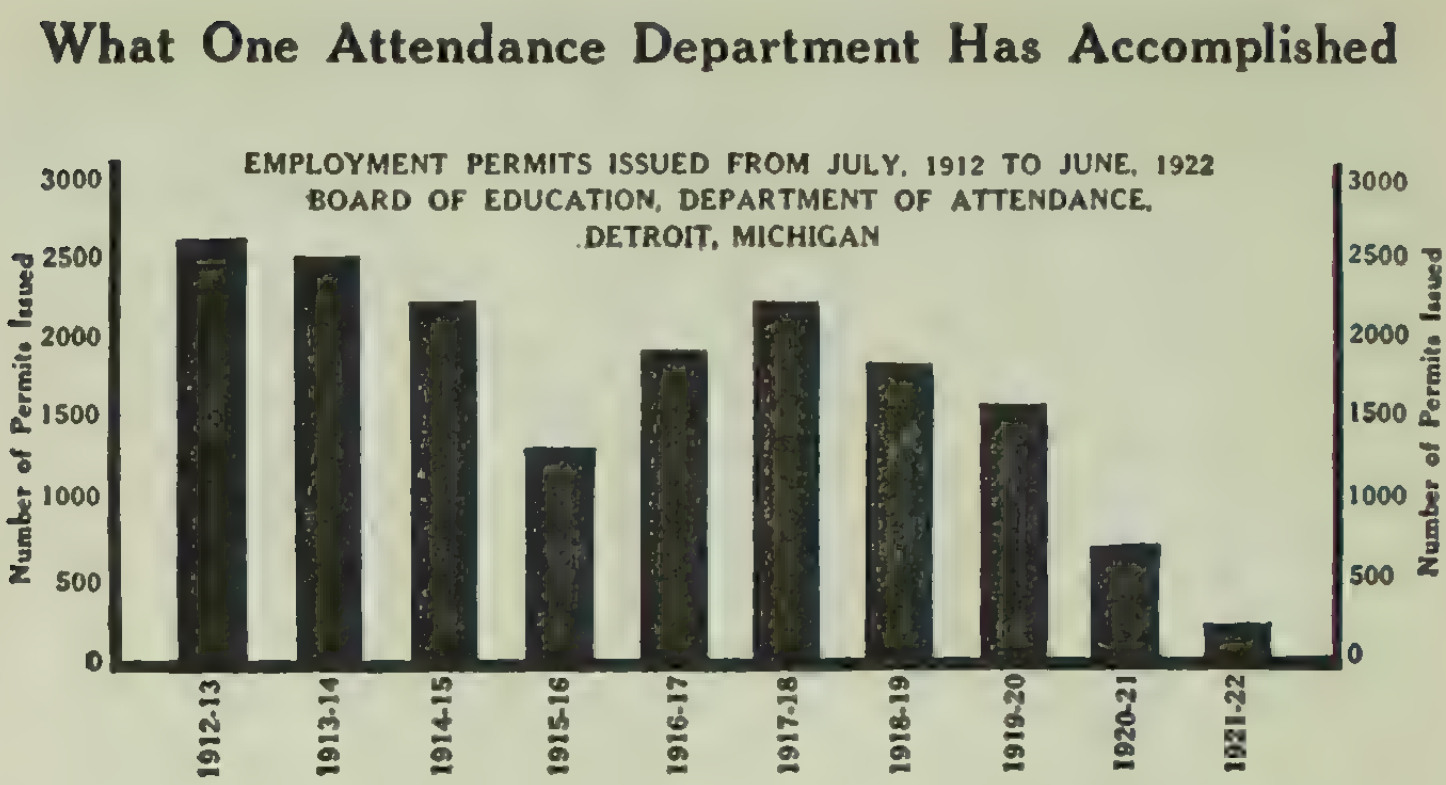


FIG. 144. COMBINATION DRAWN AND TYPE-SET CHART, SHOWING DECREASE IN EMPLOYMENT PERMITS IN DETROIT, 1912–1922.
(From *The American Child*, January, 1923.)

Charts set by the printer. Figure 144 shows a combination of a zinc etching, made from a drawing, and printer's type. This can often be done with charts that are to be printed, and is better and more appropriate than using typewriter type.

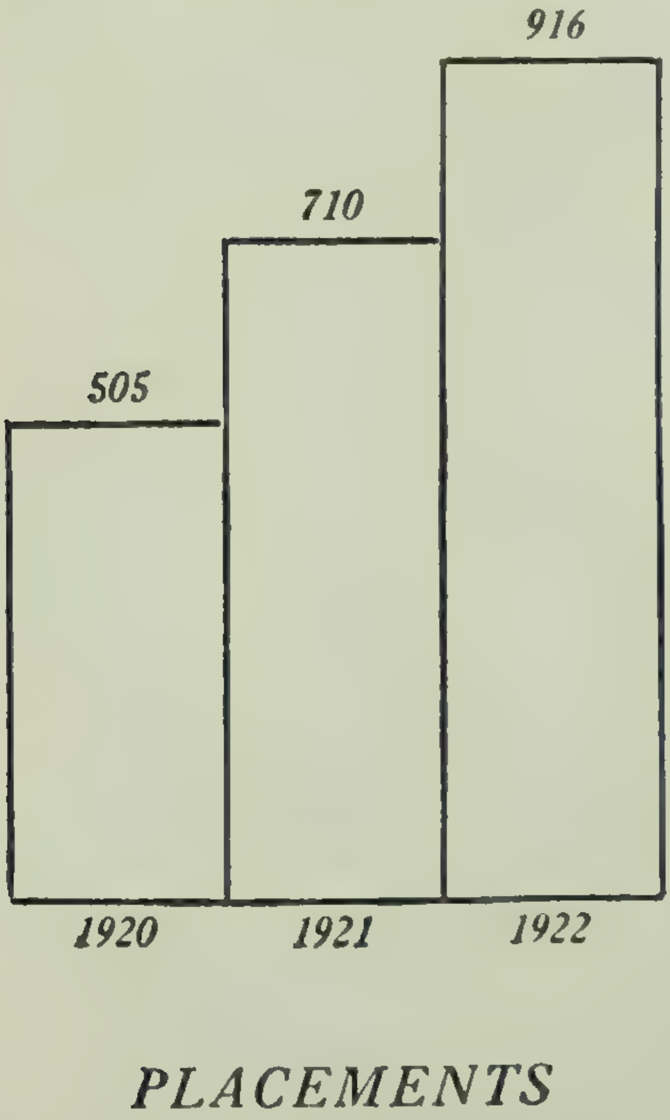


FIG. 145. CHART MADE ENTIRELY BY PRINTER, WITHOUT DRAWING
(From *Report of Pasadena Vocation Bureau*, 1923.)

Figure 145 illustrates the kind of chart which can be set up entirely by the printer, without the use of a drawing, except for a pattern. Such charts are frequently out of proportion, owing to the difficulty of cutting the rules to exact measurement and the failure of the printer to understand the importance of doing so, or because the instructions are not clear. Engravings made from drawn charts are not expensive, and in general are to be preferred. Some printers, though, are exceptionally adept in making up such charts, which are always superior to poor drawings.

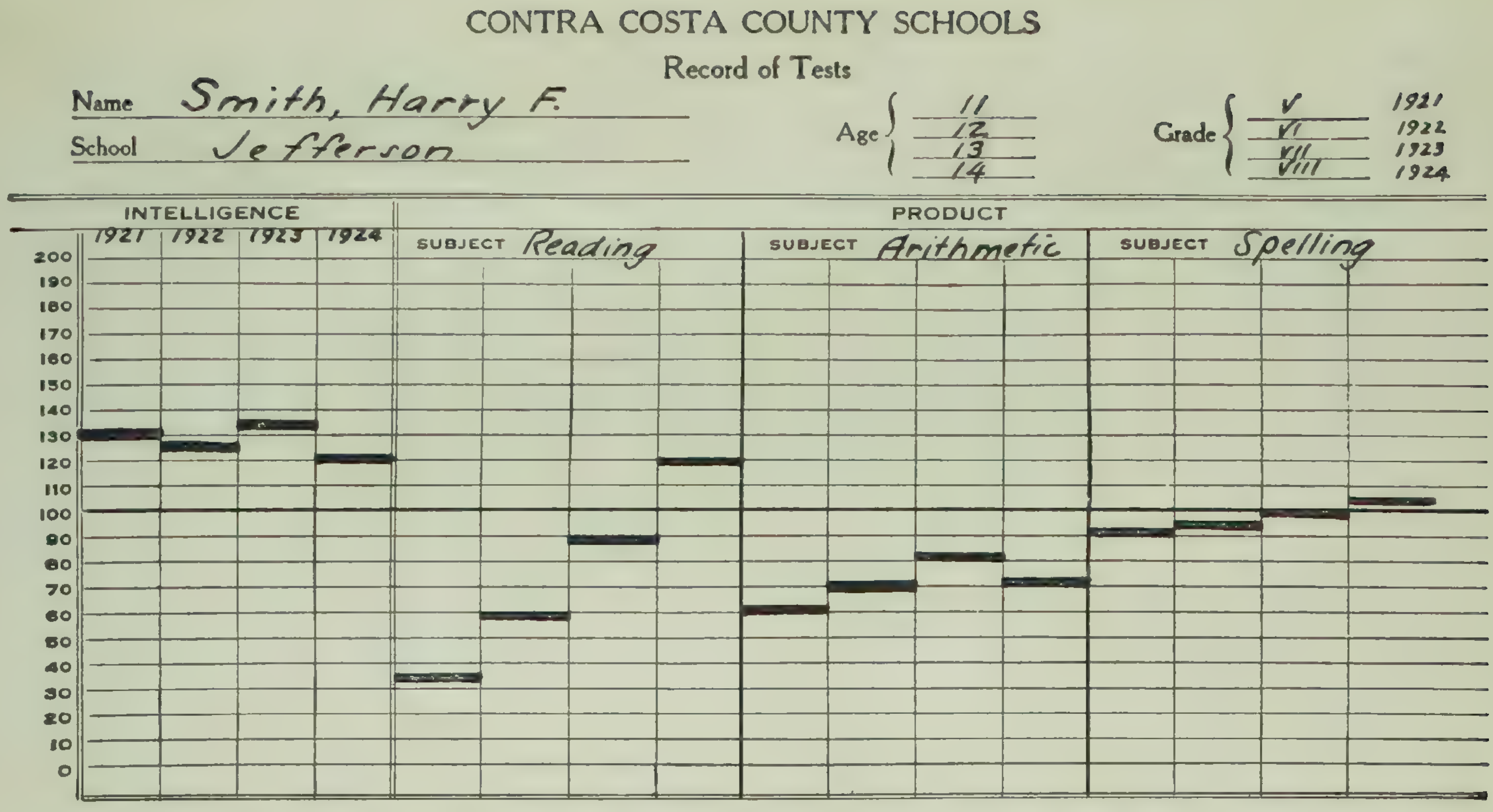


FIG. 146. INDIVIDUAL RECORD CARD for GRAPHICALLY RECORDING TEST RESULTS
(Courtesy of Dr. Raymond Franzen.)

Individual record cards. Figure 146 is a card used in keeping an individual graphic record of mental and educational tests. The first section on the left is for recording the intelligence quotient, by means of a short horizontal bar at the appropriate level. The other sections represent achievement in Reading, Arithmetic, and Spelling, respectively. Each section is divided into four columns, to provide for the records of the original test and three subsequent testings. At the extreme left is a column of figures representing the range of possible quotients, the horizontal line at 100 being heavy, inasmuch as it shows normal, or the expected degree of ability. In this illustration it will be seen that the intelligence quotient has remained fairly constant, as is usually the case, while the achievement in the school subjects began low and steadily increased in subsequent periods.

PROBLEMS FOR CHARTING

1. Show Figure 28 as a typewriter chart, patterned after Figure 140.
2. Make Figure 35 on the typewriter, using a continuous line, of proper length and placing, centered with the lettering at the left.
3. Show Figure 38 as a typewriter chart.
4. Make Figure 46 on the typewriter, using x and o to represent accelerated and retarded pupils, respectively.
5. Outline a chart to be made up by the printer, including all the instructions you think necessary to insure a proper presentation.
6. Make up a card similar to the one shown in Figure 146, illustrating the case of a bright pupil (I.Q. above 100) whose achievement in reading and arithmetic kept well up to expectations, but who is poor in spelling, with slow progress in that subject.

CHAPTER XVII

SPECIAL CHART DEVICES

(Explaining Figures 147 and 148)

The foregoing chapters relate to the principal types of charting. Fourteen methods for presenting facts graphically have been discussed and illustrated. All of these charts may be made with India ink, without the uses of special devices, and are made to appear in black and white only. The present chapter briefly describes some methods by which certain adaptions may be made to increase the usefulness and attractiveness of charts.

Color charts. Most charts are made with black ink only, because of its special adaptability for drawing, its permanence, and the uniformity of the results obtained. The black and white chart has become standard, and is to be recommended for nearly all purposes. Color charts cannot be reproduced in the usual manner, as has been pointed out in Chapter II; although it is possible, when necessary, to print in any number of colors. The process though is expensive, and the results do not often justify the difference in cost. For display charts, however, colors may sometimes be used to good advantage, due to the fact that colors more readily attract attention than black and white presentations. The increasing use of colored advertisements in magazine and bill-board advertising shows how practical use has been made of this fact, especially since experiments in the psychological laboratory have emphasized its frequency and importance.

Professor Daniel Starch, in his book on the Psychology of Advertising, says:

The attention-value of colors is in the following order: red, black, green, orange, blue, purple, yellow. Red has the greatest attention-value, black is next, while purple and yellow have the least. Apparently there are differences between the sexes, but the number of men and women is too small (in the experiments to which he refers) to make a significant comparison. It is interesting that red is first in attention-value, and also first in preference for the women and second for the men, while blue is first in preference for the men and second for the women, but it is considerably farther down the list in attention-value.

Red has greater attention-value than any other color because it

arouses greater psychological activity in the retina of the eye, and possibly because it has long been associated with war and bloodshed. Artists call it a warm color, in contrast with blue as a cold color.

In this connection it is significant to notice that red, next to black, is the most frequently used color in advertisements in which the color is not determined by the natural color of the object illustrated in the advertisement, but in which it is chosen for its power of attraction. A tabulation of colored advertisements appearing in various magazines showed that 77 per cent used red, 19 per cent brown, 8 per cent blue, 6 per cent green, 6 per cent orange, 6 per cent yellow, and 5 per cent purple.

Coloring the charts. Color charts are usually drawn first in outline, with India ink. They should be made according to the standard rules of charting, and should be complete in this form, excepting for the special designations for which the colors are to be added. Three color materials are suitable for the purpose: (1) colored waterproof ink, which is applied in the same way in which black ink is used for solid black areas; (2) water color paint, which is applied with a brush; and (3) colored crayons. Of these methods the first is recommended. Waterproof colored inks are obtainable at most stores dealing in drawing materials, put up in bottles with quill fillers, as in the case of India ink. The stoppers of the bottles are of the same color as the ink within, which aids in their ready identification and reduces the chance of error in their use.

Although the chief use of color is to make the chart attractive, the colors should not be used indiscriminately, but according to a consistent plan. In this connection Dr. Brinton's suggestion might be adopted:

It is desirable in all chart work to have certain conventions by which colors would be understood to have definite meanings. Thus, following railroad practice, red could generally be used to indicate dangerous or unfavorable conditions, and green to indicate commended or favorable conditions. Where neither commendation or adverse criticism is intended, colors such as blue, yellow, brown, etc., could be used.

To this might be added the additional suggestion that different *shades* of red and green be used to indicate degrees of favorableness or unfavorableness. Combinations of red and black might be used for this purpose; thus, in Figure 25, showing five groups of intelligence among delinquent boys, the area representing feeble-mindedness could remain in black; the borderline area could be single-hatched in black, with a uniform solid coat of red;

the dull normal area, by red alone; the average-normal area, white, and the superior area, green.

Mr. Gardner T. Swarts, in *Charts and Maps Used by Health Officers*, shows how a standard color scheme can be used to good advantage for pin maps. He proposes the following table as especially applicable to the map designation of diseases:

1. Diphtheria and Croup	Green
2. Malaria	Navy blue
3. Measles	Heliotrope
4. Whooping Cough	Slate
5. Poliomyelitis	Canary yellow
6. Scarlet Fever	Red
7. Smallpox	Brown
8. Tuberculosis	Black
9. Typhoid Fever	Orange
10. Meningitis	Lavender

He also proposes the following color scheme to represent nationalities:

1. American	Red
2. Chinese	Yellow
3. English	Blue
4. French	Lavender
5. German	Black
6. Greek	White
7. Irish	Green
8. Italian	Light green
9. Japanese	Brown
10. Mexican	Heliotrope
11. Polish	Slate
12. Portuguese	Turquoise
13. Spanish	Pink
14. Swedish	Navy blue

Cumulative charts. For administrative purposes it is desirable to have certain charts made so that new data may be added at regular intervals. For this purpose vertical bar charts (Chapter IV) and curves (Chapter VI) are most commonly used. For the use of executives who wish to see the conditions for each month or year in relation to the preceding months or years, charts may be drawn with the base line extended beyond the present date, so that only a line or column need be added for each interval. The rainfall chart (Figure 43) and the infant mortality chart (Figure 65) illustrate the type of data which can be prepared in this way.

School executives similarly could be kept graphically informed concerning average daily attendance, school costs, seasonal fluctuations in community conditions, changes in salary levels, etc.

Pin charts and maps. Individual frequency distributions (Chapter VIII) may be made up for continuous use. Thus Figure 83, showing the individual test-ratings of delinquent boys, is a cumulative chart in that a spot may be added, to represent the result of each new test, until the chart is full or the area of greatest density becomes so clogged that there is no more room. The chart could be made on a large enough scale, however, to last for a long period of time. One of the purposes of two-way individual frequency charts is to emphasize the central tendency, which may change in either direction as the data increase.

If Figure 83 is made up in the form of a wall chart, a simple and effective method of adding new cases is by the use of short pins with round distinctive heads. Pins for this purpose are obtainable in different sizes, styles, and colors, and many effective presentations have resulted from their ingenious use. Health exhibits frequently contain pin charts showing the distribution of contagious diseases, infant mortality, etc.[1] Chief of Police August Vollmer, of Los Angeles, has devised a number of pin charts to show the distribution of conditions relative to crime. One of these charts, based on a map of the city, indicated the residence of each boy in the city limits whose irregularity of conduct was reported to the police. Eventually this chart revealed the neighborhoods in which juvenile delinquency appeared to be most frequent, and the information resulted in the breaking up of several incipient "gangs," in time to prevent serious crime. The Whittier State School uses the pin map method of recording the location of boys sent out under the supervision of the placement department. The California Bureau of Juvenile Research maintained a cumulative pin map, showing the results of extensive home and neighborhood investigations by social case workers. The location of each home was indicated by the position of a pin, the color of which indicated the grading of the home, according to the Whittier scale. Red was used to indicate unfavorable conditions, green indicated favorable conditions, and white indicated average conditions, not classifiable in either of those groups. A key, or legend, at the bottom of the map explained the use of the colors.

[1] Swarts, G. T. *Charts and Maps Used by Health Officers.* Educational Exhibition Company, Providence, Rhode Island.

A school-consolidation pin map. The following excellent description of a pin map used for educational work was submitted, in 1922, to the Educational Research Bulletin of the University of Ohio by Superintendent Baer, of Cuyahoga County, Ohio:

A large scale map of Cuyahoga County, two inches to the mile, was obtained from the County Engineer's office. The school districts of the county were blocked in and colored with water color to make the district lines more prominent. Colored pins, as indicated below, were used to show the various kinds of school buildings and other facts.

In 1914 there were ninety-six small red pins, indicating one-room schools in use, and only fifteen large red pins indicating buildings of more than one room. The large pins are such that the number of rooms in the building can be lettered on with ink. In the meantime a few portables have been built, but now there are only thirty-two red pins, and seventeen of these are in the process of centralization, and will be replaced by blue pins by the end of the present school year. There are seventy-four blue pins on the map at the present time. In other words, since 1914 ninety-one one-room schools have been abandoned. A vote on the elimination of four more will be taken at the November election this fall.

Fifty-two large red pins indicate buildings of more than one room, and practically all of these have four rooms or more. Several of the original fifteen have been remodeled, or additions have been built to them.

Nineteen large white pins indicate the present high schools, only one of which is below first grade. It is a second-grade school. In 1914 there were seven first-grade, two second-grade, and five third-grade high schools in the county district.

There are twenty-two green pins indicating auditoriums, six purple pins to indicate gymnasiums, and five purple and white pins to indicate combined auditoriums and gymnasiums.

Centralization of schools is shown by red cords running from the small red or blue pins to the large red pin which represents the new school.

The mere enumeration of pins does not really convey a very good idea of the map itself, for the map presents in a very tangible way what has been done in the way of displacing one-room schools, establishing high schools, and building new buildings.

Pins are obtainable with flat heads, numbered for individual designation.[1] Thus, in Figure 83, each new boy could be represented by the test number, so that his name and other data concerning him could be found by referring to the index list.

[1] Pins and other chart materials described in this chapter may be obtained from the Educational Exhibition Company, 26 Custom House St., Providence, Rhode Island.

Charts made on paper should be mounted on a soft wood or a special base material suitable for the insertion of pins. The construction of a cellular mount material is illustrated in Figure 147. The cost of the good mounting board is more than offset by its superior advantages.

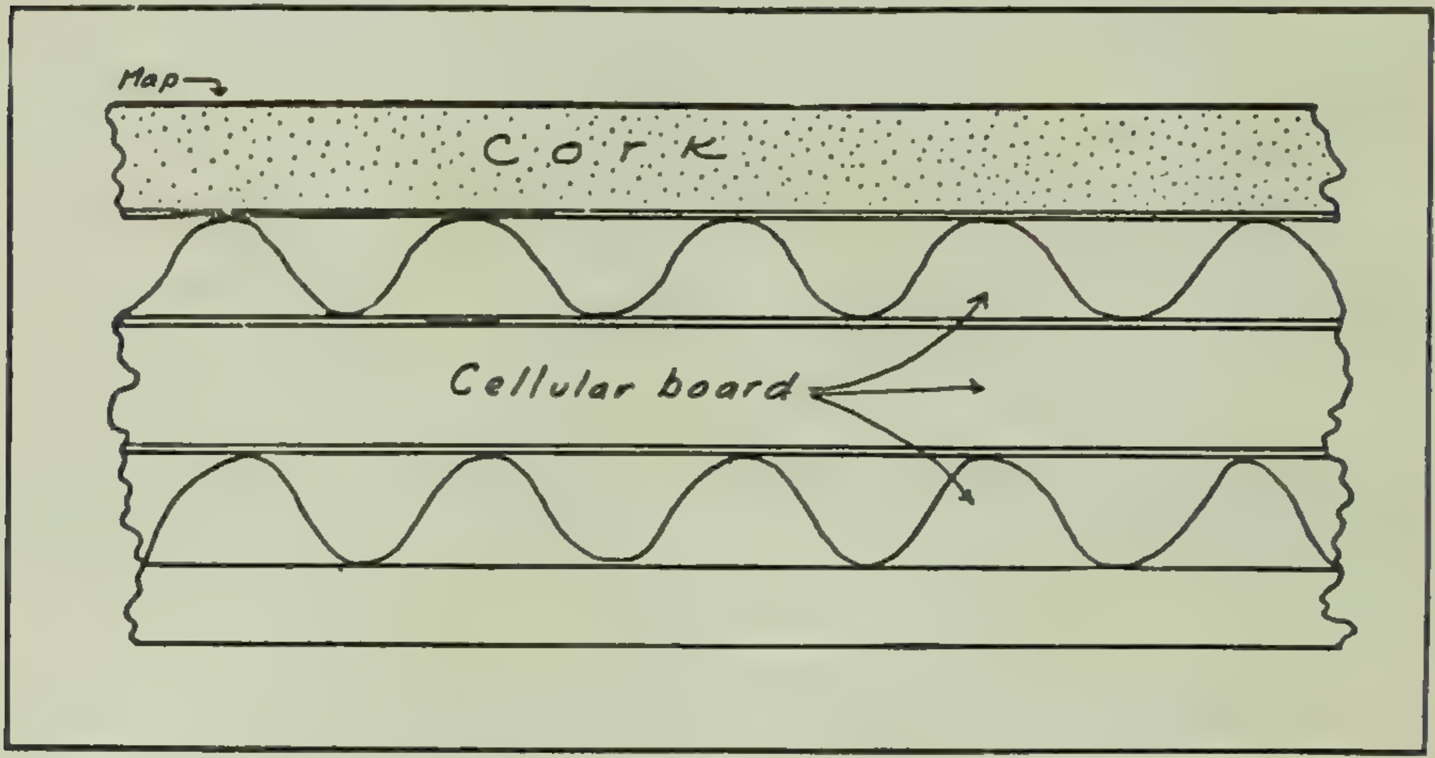


Fig. 147. Cross-Section Illustrating Construction of Cellular Board Mount for Pin Maps

(Redrawn from catalogue of Educational Exhibition Company, Providence, Rhode Island.)

Mechanical charts. Figure 148 illustrates a chart constructed so that it may be changed, according to fluctuating data. It represents the attendance, by grades, of a city school, by a series of horizontal bars. The bars are made of movable strips of thin cardboard which pass through slits in the chart at the vertical base line and at the 100 per cent line. The strips are inked in solid for a portion of their length corresponding to the distance between the zero and 100 per cent guides. Each strip may be moved horizontally so that the end of the inked-in area will be at the desired percentage. The month for which the record is being made is indicated at the top of the chart, and this also may be made changeable by means of a movable strip containing the names of all the months. The chart is similar in construction to the "perpetual" calendars which are frequently used in offices. Dr. Carter Alexander, in his *School Statistics and Publicity*, thus describes a perpetual-attendance chart of a vertical bar series used by a school principal in Alabama:

A large chart was made up on a Bristol board once for all, with the

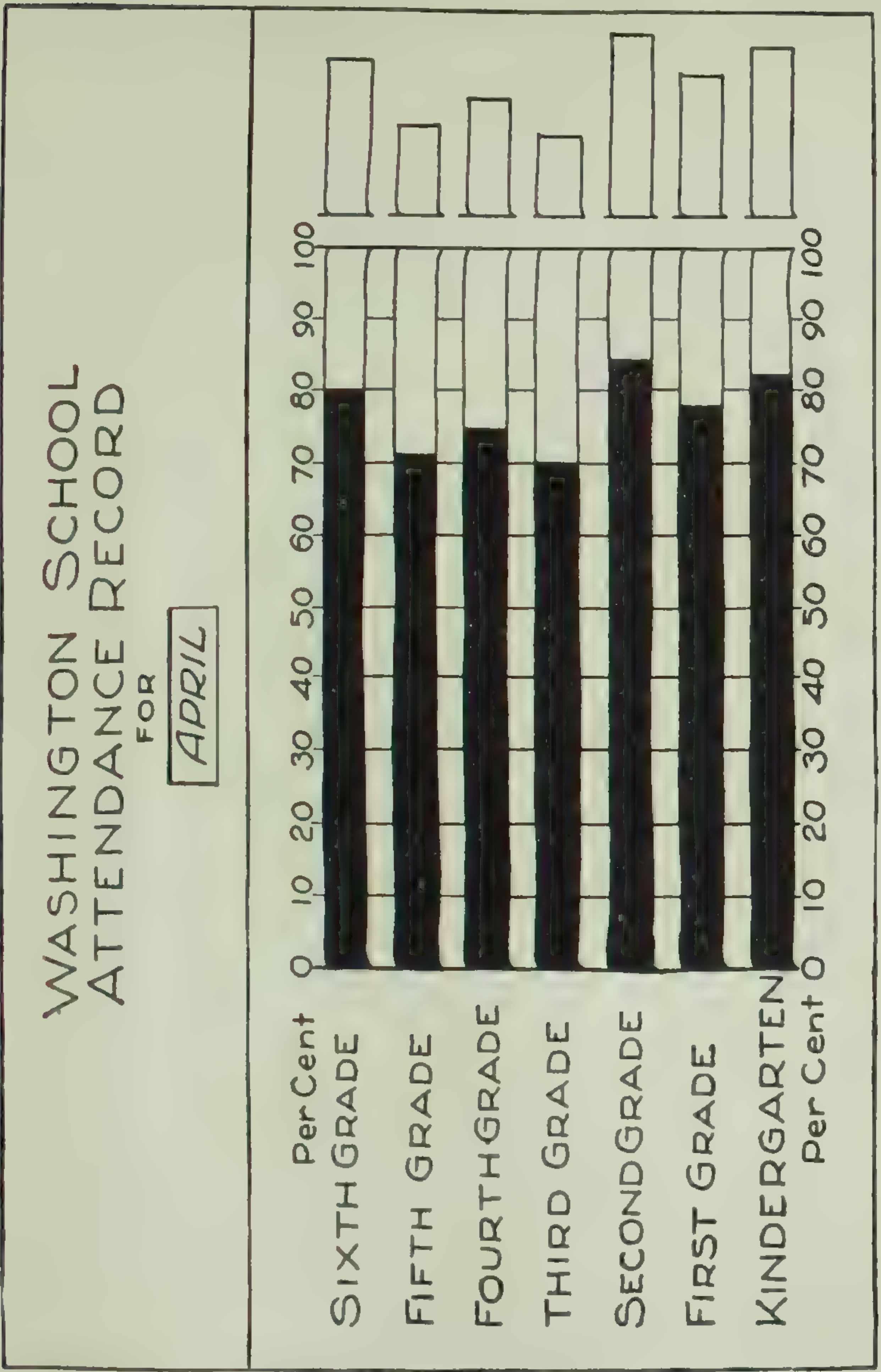


Fig. 148. Mechanical Attendance Chart for Perpetual Use

percentage scale running up on the sides. Each class was represented by a paper ribbon that came through a slit on the base line. By pulling the ribbons up and down each month, and fastening the ends with thumb tacks, the graph was quickly brought up to date. The omission of the zero line exaggerated differences, but such exaggeration was to some extent desired for emphasis. The only real drawback seems to be that one cannot compare the classes by month with such a chart. The chart as operated, however, does not need to show comparisons. The emphasis on attendance is intended to keep up attend-

ance all the time, and not to let children slack up one month because of a good record the preceding month. If, however, it is desirable to make comparisons, this can be easily done by preserving kodak pictures of the chart at various times.

An ingenious chart maker can devise many other ways in which charts may be constructed for mechanical operation, with the special advantage that they may be kept up to date, and do not have to be redrawn when the data change.

PROBLEMS FOR CHARTING

1. For experience in the use of colored inks, make up Practice Chart No. 4 (Figure 13) in outline form, and fill in three solid areas with different colors.
2. Draw an outline of Figure 25, and color according to the suggestion in this chapter.
3. Draw Figure 47 in four colors, with appropriate designations in the key.
4. Draw Figure 86 in colors, with appropriate use of key.
5. Draw Figure 105 in colors, designating diphtheria, typhoid fever, and tuberculosis according to the Swarts outline, given in this chapter.
6. Obtain recent data for the continuation of Figure 60, and redraw in anticipation of its use for ten years to come.
7. Obtain the chronological and mental ages of the children in a small city school, and make up a pin map, following the pattern of Figure 83. Use colors for special designations determined by the character of the group.
8. Make a mechanical chart according to Dr. Alexander's description, quoted in this chapter. An illustration of the chart will be found on page 298, of his *School Statistics and Publicity.*

CHAPTER XVIII

RULES FOR JUDGING CHARTS

Rules for standard graphic procedure. Before the publication of Brinton's *Graphic Methods for Presenting Facts*, charts were made according to the individual tastes of chart makers, and no plans or rules were consistently followed. Realizing the need for standardizing graphic procedure, Dr. Brinton formulated a set of rules which have served this purpose very well. More recently the American Statistical Society has adopted many of the rules, especially those relating to the construction of curves.

The following list, based on Brinton's original publication, is of sufficient importance to warrant reproduction here:

1. Avoid using areas or volumes when representing quantities. Presentations read from only one dimension are the least likely to be misinterpreted.
2. The general arrangement of a chart should proceed from left to right.
3. Figures on the horizontal scale should always be placed at the bottom of the chart. If needed, the scale may be repeated at the top.
4. Figures for the vertical scale should always be placed at the left of the chart. If needed, the scale may be repeated at the right.
5. Wherever possible, include in the chart the numerical data from which the chart was made.
6. If numerical data cannot be included in the chart, it is well to show the numerical data in tabular form accompanying the chart.
7. All lettering and all figures should be so placed as to read from base upward, or from left to right.
8. A column of figures representing dates should be arranged with the earliest date at the top.
9. Separate columns of figures, with each column relating to a different date, should be arranged to show the column for the earliest date at the left.
10. When charts are colored, green should be used to represent conditions that are favorable or to be commended, and red for features that are undesirable or to be adversely criticized.
11. As a general rule, the horizontal scale for curves should read from left to right, and the vertical scale from bottom to top.
12. For curves drawn on arithmetically ruled paper, the vertical

scale, wherever possible, should be so selected that the zero line will show on the chart.

13. The zero line of the vertical scale for a curve should be a much broader line than the average coördinate lines.
14. If the zero line of the vertical scale cannot be shown at the bottom of a curve chart, the bottom line should be a slightly wavy line, indicating that the field has been broken off and does not reach to zero.
15. When the scale of a curve chart refers to percentages, the line at 100 per cent should be a broad line of the same width as the zero base line.
16. When the horizontal scale for a curve begins at zero, the vertical line at zero (usually the left-hand of the field) should be a broad line.
17. When the horizontal scale expresses time, the lines at the left-hand edge of a curve chart should not be made heavy, since a chart cannot be made to include the beginning or the end of time.
18. When curves are to be printed, do not show any more coördinate lines than necessary for the data and to guide the eye. Lines one-fourth inch apart are usually sufficient for this purpose.
19. Make curves with much broader ruling than the coördinate ruling, so that the curves may be clearly distinguished from the background.
20. Whenever possible have a vertical line of the coördinate ruling for each point plotted on a curve, so that the vertical lines may show the frequency of the data observations.
21. If there are not too many curves drawn in one field it is desirable to show at the top of the chart the figures representing the value of each point plotted in the curve.
22. Make the title of the chart so complete and so clear that its misinterpretation will be impossible.

Checking list for graphic presentations. Brinton also gives a check-list for checking up chart work, to see if the chart is being properly constructed, that also is worth reproducing here:

1. Are the data of the chart correct?
2. Has the best method been used for showing the data?
3. Are the proportions of the chart the best possible to show the data?
4. When the chart is reduced in size by photo-engraving, will the proportions be those best suited to the space in which it must be printed?
5. Are the proportions such that there will be sufficient space for the title of the chart when it has been reduced to final printing size?

6. Are all scales in place?
7. Have the scales been selected and placed in the best possible manner?
8. Are the points accurately plotted?
9. Are the numerical figures shown as a portion of the data for the chart?
10. Have the figures for the data been copied correctly?
11. Can the figures for the data be added and the total shown?
12. Are all dates accurately shown?
13. Is the zero of the vertical scale shown on the chart?
14. Are all zero lines and 100 per cent lines made broad enough?
15. Are all lines on the chart broad enough to stand the reduction of the size used in printing?
16. Does the lettering appear large enough and black enough, when seen under a reducing glass in the size which will be used for printing?
17. Is all lettering placed on the chart in the proper directions for reading?
18. Is cross-hatching well made, with lines evenly spaced?
19. Is a key or legend necessary?
20. Does the key or legend correspond with the drawing?
21. Is there a complete title, clear and concise?
22. Is the drafting work of good quality?
23. Have all pencil lines which might show in the engraving been erased?
24. Is there any portion of the illustration which should be cropped off, to save space?
25. Are the instructions for the final size of the plate so given that the engraver cannot make a mistake?
26. Is the chart in every way ready to mark O.K.?

The foregoing rules are merely suggestions for use in planning the chart and checking it over in completed form. Throughout this text are many other rules and cautions, which have been presented in connection with the discussion of the several types of charting. The worker who is interested in the practical value of his product will see to it that his efforts have been directed toward making the presentation as effective as possible.

Grading-scale for charts. Charts, like all other products of learning, are subject to the laws of variation and individual differences. No two persons have the same ability, and no two can realize exactly the same degree of achievement. There is in process of development a scale for grading the quality of graphic

representation, based on the work of university students. In the meantime, the writer has applied the following classification to the work submitted:

A. First-class work. Professional quality. Acceptable for any purpose.
B. Good work, but with evident imperfections. Acceptable for publication, however, to illustrate a magazine article.
C. Mediocre work, barely acceptable for reproduction or display.
D. Unsuitable for reproduction or display, but passable for purposes of a practice course.
E. Failure. Unacceptable for any purpose.

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